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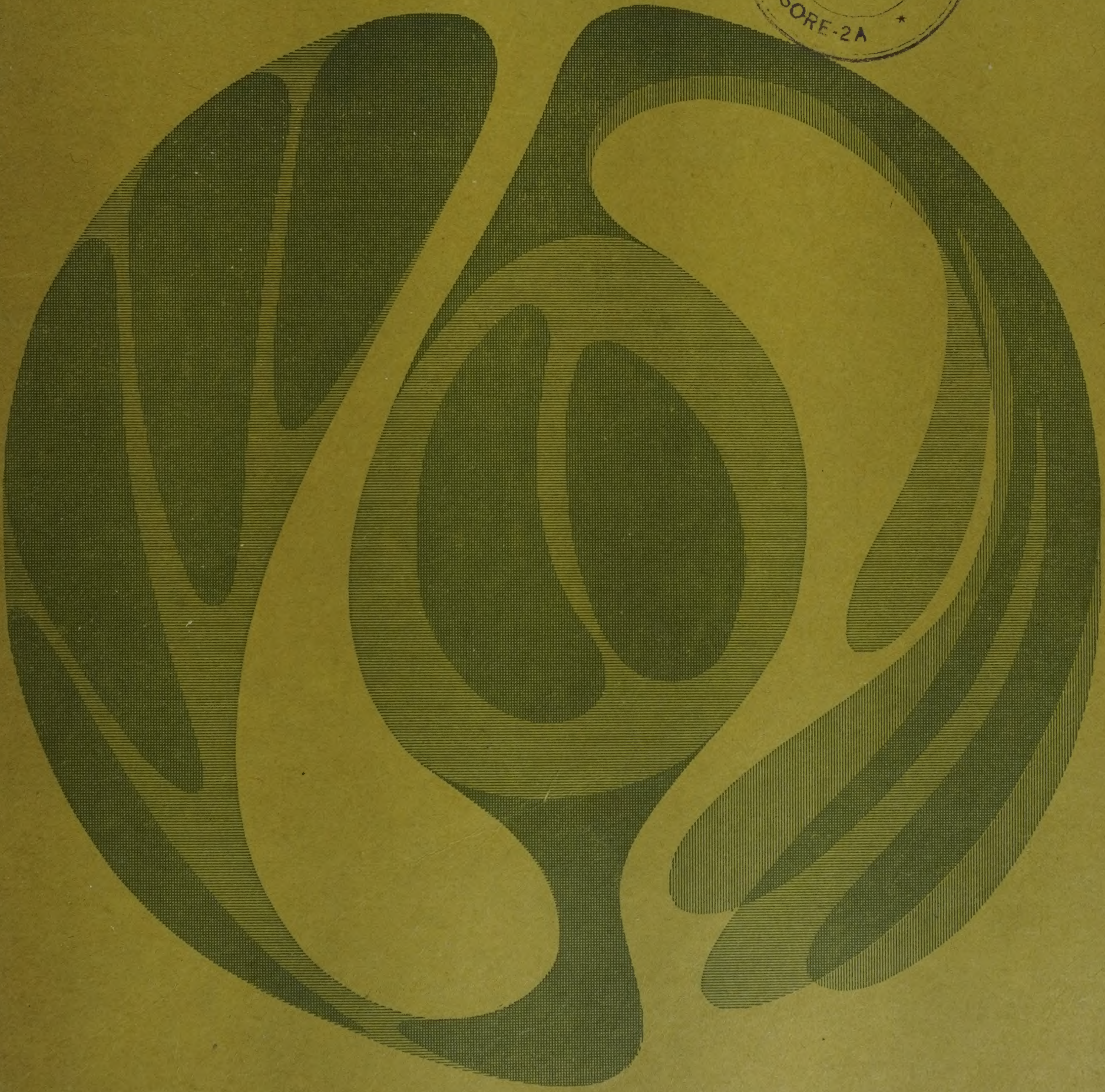
Tropical Products Institute

G146

Economic aspects of small-scale fish freezing



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Economic aspects of small-scale fish freezing

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November 1980

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Overseas Development Administration

This report was produced by the Tropical Products Institute, a British Government organisation which co-operates with developing countries in helping them to derive greater benefit from their plant and animal resources. It specialises in post-harvest problems and will be pleased to answer requests for information and advice addressed to the Director.

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SUMMARY

Economic aspects of small scale fish freezing

1 This report is concerned with the operation of small to medium-scale fish freezing plants and is intended as a guide to potential investors concerned with the identification, appraisal, financing and implementation of fish processing projects.

2 The basis of the report is a series of physical and financial cost models. Factor costs pertinent to a particular developing country have been applied for purposes of analysis. However, the physical requirements are set out to enable users of the report to apply factor costs appropriate to their own locality.

3 The general principles of the freezing of fish are discussed and the different methods commercially used are described. In particular, the methods of contact freezing and blast freezing are examined although only the former has been considered in the design of the cost models. It should be noted that throughout this report certain assumptions have been made which in practice may be over-simplifications. The main assumption has been that all the fish products being frozen are suitable for horizontal plate freezing. Horizontal plate freezers are suitable only for freezing fish of uniform size and shape which are to be distributed and marketed as blocks of frozen fish. Horizontal plate freezers are therefore well suited to the production of blocks of frozen prawns and are often used in industry for this purpose. To freeze scale fish, however, in a horizontal plate freezer requires that the fish should be of uniform, fairly small, size and shape and need to be packed as blocks. Fish such as sardines and herring may be suitable for this. This report is therefore not a recommendation to use horizontal plate freezers in all cases. There are many situations where fish are of many shapes and sizes and are marketed as individual fish. In this situation air blast freezers rather than horizontal plate freezers are the obvious choice and this must be borne in mind when reading this report.

4 Where there is doubt as to the most suitable type of freezer for a particular operation advice can be obtained from the Tropical Products Institute.

5 Four basic cost models have been developed to illustrate the effect of differences in product mix and scale of operation:

- (i) Model 1 – producing 225 tonnes of prawns a year from two 8-hour shifts/day operating for 250 days a year.
- (ii) Model 2 – producing 202.5 tonnes of prawns a year from two 8-hours shifts/day operating for 150 days/year and 840 tonnes of whole fish/year from two 8-hour shifts/day operating for 250 days a year.
- (iii) Model 3 – producing 2 240 tonnes of whole fish a year from two 8-hour shifts/day operating for 250 days/year.

(iv) Model 4 – producing 3 360 tonnes of whole fish a year from three 8-hour shifts/day operating for 250 days/year.

6 For prawns, the effect of the production of raw whole and of raw headless products has been examined.

7 The aim of the analysis of the cost models has been to compute the prices that could be paid to fishermen for prawns and fish given that all other costs/prices (including those of the end product) are known. For purposes of computing the raw material prices, the financial requirements imposed upon the four cost models in a sensitivity analysis have been that each plant should show an Internal Rate of Return (IRR) of 10 per cent or 20 per cent, assuming a project life of 15 years. Discounted cash flow techniques have been applied to compute the amount available each year for the purchase of prawns or fish and hence the price per tonne that could be paid for these raw materials.

8 Financial sensitivity to a range of end-product prices has been shown in the analysis of the cost models. For prawns the end product prices used range between £1 000/tonne and £4 000/tonne, for fish the range is £150/tonne to £250/tonne. In addition to these variations, the sensitivity of the performance of the cost models has been tested for changes in the value of the most significant items of the operating costs. Thus, for Model 1 the effect of a reduction in labour costs by one third has been tested, for Model 2 the effects of a general raising and lowering of total operating costs by 15 per cent have been tested, and for model 3 and 4 the effects of raising and lowering electricity costs by 50 per cent have been tested.

9 For Model 1, for the above range of end product prices, the derived purchase price for prawns ranges from £600/tonne to £3 450/tonne with a 10 per cent IRR, assuming whole raw prawns as the end product. With a 20 per cent IRR these purchase prices range from £560/tonne to £3 410/tonne. The reduction in labour costs adds some £50 to £60/tonne to the derived purchase price. In all cases, adopting the assumption that raw headless prawns are the end product gives a derived purchase price at the factory gate some 60 per cent of that applying when raw whole prawns are the end product.

10 Model 2 takes prawn purchase prices as in Model 1 in order that derived fish purchase prices may be computed. These derived fish prices depend upon the end product prices for prawns and fish and range from £20/tonne up to £173/tonne with a 10 per cent IRR and from £10/tonne up to £163/tonne with a 20 per cent IRR. A general lowering or raising of total operating costs by 15 per cent has the effect of raising or lowering the derived fish purchase price by approximately £10/tonne in all cases.

11 For Model 3, depending on the end product price adopted, the derived fish purchase price varies from £72/tonne to £170/tonne with a 10 per cent IRR and from £62/tonne to £160/tonne with a 20 per cent IRR. An increase or a reduction in power costs by 50 per cent results in a decrease or an increase in the raw material purchase price of approximately £11–£12/tonne.

12 Model 4 is a simple expansion of Model 3 to enable 3-shift rather than 2-shift production and includes an increase in freezing and icemaking capacity. Derived fish purchase prices range between £82/tonne and £180/tonne with a 10 per cent IRR and between £73/tonne and £171/tonne with a 20 per cent IRR. These figures are higher than for Model 3 and reflect the benefits of a more intensive and efficient use of employed capital and equipment. An increase or a reduction in power costs by 50 per cent would result in a decrease or an increase in raw material prices of approximately £9/tonne.

RESUMÉ

Aspects économiques de la congélation de poisson sur une petite échelle

1 Ce rapport concerne le fonctionnement d'usines de congélation de poisson de capacité faible à moyenne et il est destiné à servir de guide à des actionnaires éventuels en ce qui concerne la caractérisation, l'appréciation, le financement et la mise en oeuvre de projets de traitement du poisson.

2 Le rapport a pour base une série de modèles physiques et financiers. Des frais opérationnels se rapportant à un pays en voie de développement particulier ont été appliqués pour les besoins de l'analyse. Cependant, les exigences physiques sont présentées pour permettre aux utilisateurs du rapport d'appliquer les frais opérationnels de façon pertinente à leur propre localité.

3 Les principes généraux de la congélation du poisson sont discutés et les différentes méthodes commercialement utilisées sont décrites. En particulier, on examine les méthodes de congélation par contact et de congélation par soufflage, bien que seule la première ait été prise en considération dans la conception des modèles de frais. Il faut remarquer que tout au long de ce rapport on a fait certaines hypothèses qui, en pratique, peuvent se révéler comme des sur-simplifications. La première hypothèse a été que tous les produits de poissons qui sont congelés conviennent à la congélation sur plaques horizontales. Les congélateurs à plaques horizontales conviennent uniquement pour la congélation de poissons de taille et de forme uniformes, qui sont destinés à être distribués et commercialisés sous forme de blocs de poisson congelé. Par conséquent, les congélateurs à plaques horizontales conviennent bien pour la production de blocs de crevettes congelées et ils sont souvent utilisés dans l'industrie dans ce but. Mais pour congeler du poisson à écailles dans un congélateur à plaques horizontales, il faut que les poissons soient de taille assez petite et uniforme et de forme régulière et ils doivent être entassés en blocs. Les poissons comme les sardines et les harengs peuvent convenir pour cela. Par conséquent, dans ce rapport on ne recommande pas l'utilisation de congélateurs à plaques horizontales dans tous les cas. Il existe beaucoup de situations où des poissons sont de tailles et de formes très différentes et sont commercialisés à la pièce. Dans ces conditions, le choix doit manifestement aller aux congélateurs par soufflage d'air plutôt qu'aux congélateurs à plaques horizontales, et il faut en tenir compte à la lecture de ce rapport.

4 Lorsqu'il y a un doute quant au choix du type de congélateur convenant le mieux à une opération donnée, on peut demander conseil à l'Institut des Produits Tropicaux.

5 Quatre modèles de prix de base ont été élaborés pour illustrer l'effet des différences d'une production mixte et de l'importance de l'opération:

(i) Modèle 1 — Production de 225 tonnes de crevettes par an par 2 équipes de 8 heures par jour travaillant 250 jours par an.

(ii) Modèle 2 — Production de 202,5 tonnes de crevettes par an par 2 équipes de 8 heures/jour travaillant 150 jours par an et de 840 tonnes de poisson entier/an par 2 équipes de 8 heures/jour travaillant 250 jours par an.

(iii) Modèle 3 — Production de 2.240 tonnes de poisson entier par an par 2 équipes de 8 heures/jour travaillant 250 jours par an.

(iv) Modèle 4 — Production de 3.360 tonnes de poisson entier par an par 3 équipes de 8 heures/jour travaillant 250 jours par an.

6 Pour les crevettes, on a examiné l'effet de la fabrication de produits bruts entiers et de produits bruts sans tête.

7 Le but de l'analyse des modèles de frais était de calculer les prix qui pourraient être payés aux pêcheurs pour les crevettes et le poisson, supposant que tous les autres frais/prix (y compris ceux du produit fini) sont connus. Pour les besoins du calcul des prix des matières premières, les exigences financières imposées aux quatre

modèles de frais dans une analyse de sensibilité ont été que chaque usine doit présenter une marge de bénéfice interne de 10% ou 20%, admettant une durée de vie du projet de 15 ans. Des techniques de mouvement de capitaux à l'escompte ont été appliquées pour calculer la quantité disponible chaque année pour l'achat de crevettes ou de poisson et, par suite, le prix par tonne qui pourrait être payé pour ces matières premières.

8 On a montré la sensibilité financière à une limite des prix des produits finis dans l'analyse des modèles de frais. Pour les crevettes, les prix des produits finis utilisés s'échelonnent entre Ⱡ 1.000/tonne et Ⱡ 4.000/tonne, pour le poisson, les limites sont de Ⱡ 150/tonne à Ⱡ 250/tonne. En plus de ces variations, la sensibilité des performances des modèles de frais a été contrôlée pour des modifications de la valeur des éléments les plus importants des frais opérationnels. Ainsi, pour le Modèle 1, on a testé l'effet d'une réduction d'un tiers des frais de main d'oeuvre, pour le Modèle 2, on a testé les effets d'une augmentation ou d'une réduction générale des frais opérationnels totaux de 15%, et pour les Modèles 3 et 4, on a testé les effets de l'augmentation ou de la réduction de 50% des frais d'électricité.

9 Pour le Modèle 1, pour les limites ci-dessus des prix du produit fini, le prix déduit d'achat des crevettes s'échelonne entre Ⱡ 600/tonne et Ⱡ 3.450/tonne avec une marge de bénéfice interne de 10%, en prenant les crevettes brutes entières comme produit fini. Avec une marge de bénéfice interne de 20%, ces prix d'achat s'échelonnent entre Ⱡ 560/tonne et Ⱡ 3.410/tonne. La réduction des frais de main d'oeuvre ajoute environ Ⱡ 50 à Ⱡ 60/tonne au prix d'achat déduit. Dans tous les cas, le fait d'adopter l'hypothèse que les crevettes brutes sans têtes constituent le produit fini donne un prix d'achat déduit, aux portes de l'usine, représentant environ 60% de celui s'appliquant lorsque les crevettes brutes entières constituent le produit fini.

10 Le Modèle 2 prend les prix d'achat des crevettes comme dans le Modèle 1 afin que les prix déduits d'achat du poisson puissent être calculés. Ces prix déduits du poisson dépendent des prix du produit fini pour les crevettes et le poisson et s'échelonnent entre Ⱡ 20/tonne et Ⱡ 173/tonne avec une marge de bénéfice interne de 10% et entre Ⱡ 10/tonne et Ⱡ 163/tonne pour une marge de bénéfice interne de 20%. Une diminution ou une augmentation générale de 15% des frais opérationnels totaux a pour effet une augmentation ou une diminution du prix déduit d'achat du poisson d'environ Ⱡ 10/tonne dans tous les cas.

11 Pour le Modèle 3, suivant le prix adopté pour le produit fini, le prix déduit d'achat du poisson varie de Ⱡ 72/tonne à Ⱡ 170/tonne avec une marge de bénéfice interne de 10% et de Ⱡ 62/tonne à Ⱡ 160/tonne avec une marge de bénéfice interne de 20%. Une augmentation ou une réduction de 50% des frais d'électricité entraîne une diminution ou une augmentation du prix d'achat des matières premières d'environ Ⱡ 11 à Ⱡ 12/tonne.

12 Le Modèle 4 est un simple développement du Modèle 3 pour permettre la production par 3 équipes au lieu de 2 équipes et il comprend une augmentation de la capacité de congélation et de production de glace. Les prix déduits d'achat du poisson s'échelonnent entre Ⱡ 82/tonne et Ⱡ 180/tonne avec une marge de bénéfice interne de 10% et entre Ⱡ 73/tonne et Ⱡ 171/tonne avec une marge de bénéfice interne de 20%. Ces chiffres sont plus élevés que pour le Modèle 3 et reflètent les avantages d'une utilisation plus intensive et plus efficace du capital et de l'équipement employés. Une augmentation ou une réduction de 50% des frais d'électricité entraînerait une diminution ou une augmentation des prix des matières premières d'environ Ⱡ 9/tonne.

RESUMEN

Aspectos económicos de la congelación de pescado a pequeña escala

1 Este informe está dedicado al estudio de la explotación de plantas de congelación de pescado a pequeña y mediana escala, y se ha llevado a cabo con el fin de ayudar a los posibles inversores interesados en la identificación, evaluación, financiación y puesta en marcha de proyectos para la elaboración de pescado.

2 El informe se ha compilado a base de una serie de modelos tangibles y de costo financiero. Los gastos de factores pertinentes a cierto país dado en estado de desarrollo han sido aplicados para los fines de estudio. No obstante, los requerimientos físicos se han clasificado para permitir que los usuarios del informe puedan aplicar los gastos de factores apropiados a su propia localidad.

3 Los principios generales de la congelación de pescado son estudiados, y se describen los distintos métodos empleados comercialmente. Se examinan en particular los métodos de congelación por contacto y por chorro de aire, si bien solamente el primero de éstos ha sido tenido en cuenta en el diseño del modelo de coste. Debe observarse que en la totalidad de este informe se han tomado por descontadas ciertas suposiciones, las cuales en la práctica pudieran resultar simplificaciones excesivas. La suposición principal ha sido que todas las variedades de pescado destinadas a la congelación son apropiadas para el congelado por placa horizontal. Las congeladoras por placa horizontal son apropiadas solamente para congelar el pescado de un tamaño y forma uniformes, para ser distribuido y comercializado como bloques de pescado congelado. Las congeladoras por placa horizontal son así pues apropiadas para la producción de bloques de gambas y son con frecuencia empleadas por la industria para este fin. Para poder congelar pescado de escama en una congeladora por placa horizontal, el tamaño deberá ser uniforme, algo pequeño y de una forma adecuada para que pueda ser empaquetado en la forma de bloques. Las sardinas y los arenques, por ejemplo, podrían ser appropiados para esto. Este informe así pues no consiste en una recomendación basada en el uso de congeladoras por placa horizontal en todos los casos. Existen numerosos casos en los cuales el pescado puede adoptar muchas formas y tamaños, y por lo tanto se comercializan como pescados individuales. En estos casos, el uso de congeladoras por chorro de aire será naturalmente más apropiado que el uso de las congeladoras por placa horizontal., y este aspecto deberá ser tenido en cuenta cuando se estudie el presente informe.

4 En los casos en que se tengan dudas sobre el tipo más apropiado que ha de usarse para una aplicación particular dada, podrá obtenerse asesoramiento si se solicita del Instituto de Productos Tropicales.

5 Se han desarrollado cuatro modelos de costo básicos con el fin de ilustrar el efecto de las diferencias en la mezcla de productos y la magnitud de la operación:

- (i) Modelo 1 – para la producción de 225 toneladas de gambas por año con dos relevos de ocho horas al día, trabajando 250 dias al año.
- (ii) Modelo 2 – para la producción de 202,5 toneladas de gambas por año con dos relevos de ocho horas al día, trabajando 150 días al año y 840 toneladas de pescado entero al año con dos relevos de ocho horas al día trabajando ·250 días al año.
- (iii) Modelo 3 – Para la producción de 2.240 toneladas de pescado entero al año con dos relevos de ocho horas al día trabajando 250 días al año.
- (iv) Modelo 4 – Para la producción de 3.360 toneladas de pescado entero al año con tres relevos de ocho horas al día, trabajando 250 días al año.

6 Para las gambas fue analizado el efecto de la producción de productos enteros brutos y de productos sin cabeza brutos.

7 El objetivo de los análisis de los modelos de costo ha sido calcular los precios que podrían pagarse al pescador por las gambas y el pescado suponiendo que se conozcan

todos los demás costos/precios (incluidos los del producto final). Para fines de calcular los precios de las materias primas, los requerimientos financieros impuestos sobre los cuatro modelos de costo en un análisis de sensibilidad han sido que cada una de las plantas deberá mostrar un porcentaje interior de reembolso (IRR) del 10% ó del 20%, suponiendo una duración de proyecto de 15 años.

Se han empleado técnicas de flujo de caja descontado para calcular la cantidad disponible cada año para la adquisición de gambas o de pescado y de esto el precio por tonelada que podría pagarse por estas materias primas.

8 En el análisis de los modelos de costo se ha mostrado la sensibilidad financiera con arreglo a una gama de precios de productos finales. Para la gamba, los precios de producto final empleados fluctúan desde 1000 libras esterlinas por tonelada y 4.000 libras esterlinas por tonelada, mientras que para el pescado la gama varía desde 150 libras esterlinas a 250 libras esterlinas por tonelada. Además de estas variaciones, la sensibilidad del comportamiento de los modelos de costo ha sido comprobada en comparación del cambio efectuado en el valor de los artículos más importantes que influyen en los gastos de explotación. Así pues, para el Modelo 1 se comprobó el efecto de una reducción en los gastos de mano de obra de un tercio, para el Modelo 2 se comprobaron los efectos de una subida y una bajada general de los gastos totales de explotación de un 15%, y para los Modelos 3 y 4 se comprobaron los efectos de una subida y una bajada de los gastos de electricidad de un 50%.

9 Para el Modelo 1, y para la gama de precios de productos finales ya mencionada el precio de compra derivado para gambas fluctúa desbe 600 libras esterlinas por tonelada a 3.450 libras por tonelada con un 10% de IRR, suponiendo gambas enteras en bruto como producto final. Con un 20% de IRR, estos precios de compra fluctúan desde 560 libras por tonelada a 3.410 libras por tonelada. La reducción de gastos de mano de obra añade de 50 a 60 libras por tonelada al precio de compra derivado. En todos los casos la adopción de la suposición de gambas crudas sin cabeza como producto final arroja un precio de compra derivado fuera de fábrica de un 60% del aplicado cuando las gambas crudas enteras son el producto final.

10 El Modelo 2 considera los precios de compra de gambas como en el Modelo 1 con el fin de poder calcular los precios de compra de pescado derivados. Estos precios de pescado derivados dependerán de los precios de producto final para las gambas y el pescado y fluctúan desde 20 a 173 libras esterlinas por tonelada con un 10% de IRR y desde 10 a 163 libras esterlinas por tonelada con un 20% de IRR. Una bajada o subida general de los gastos totales de explotación de un 15% ejerce el efecto de subir o de bajar el precio de compra de pescado derivado en aproximadamente 10 libras esterlinas por tonelade en todos los casos.

11 Para el Modelo 3, dependiendo del precio de producto final adoptado, el precio de compra de pescado derivado varía desde 72 libras esterlinas por tonelada a 170 libras esterlinas por tonelada con un 10% de IRR, y desde 62 libras esterlinas por tonelada a 160 libras esterlinas por tonelada con un 20% de IRR. Un aumento o reducción en los gastos de energía de un 50% resulta en una bajada o subida del precio de compra de la materia prima de aproximadamente 11—12 libras esterlinas por tonelada.

12 El Modelo 4 es una simple prolongación del Modelo 3 para permitir la producción a tres relevos en lugar de dos, e incluye un aumento en la capacidad de congelación y la fabricación de hielo. Los precios de compra de pescado derivado fluctúan entre 82 y 180 libras esterlinas por tonelada con un 10% de IRR y entre 73 y 171 libras esterlinas por tonelada con un 20% de IRR. Estas cifras son superiores a las correspondientes para el Modelo 3 y reflejan los beneficios de un uso más eficaz e intensivo del capital invertido y de los equipos. Un aumento o reducción en los gastos de energía de un 50% resultaría en una bajada o subida del precio de compra de materia prima de aproximadamente 9 libras esterlinas por tonelada.

Section 1

Investment and the fisheries sector

INTRODUCTION

1.1 This is the first of two reports produced by the Tropical Products Institute which deal with the economic aspects of fish processing. This report is concerned with the operation of small to medium-scale fish freezing plants. The second report examines fish canning.

1.2 It is hoped that both this report and the report on fish canning will be of use to those concerned with the appraisal of fish processing projects and as such it is principally intended for the guidance of those involved in the identification, appraisal, financing and implementation of such projects within the overall context of national fishery development programmes.

1.3 The report is not intended to provide a set of technical blueprints for the establishment of fish freezing plants in the tropics, nor does it attempt to suggest that the examples of plants described and analysed herein are universally viable from a financial/economic viewpoint. Although the report provides details of capital equipment and operational requirements that, in certain circumstances, would be appropriate for the functioning of such plants at selected levels of throughput, this element is secondary to the main purpose of the study which is to examine the essential economic framework of the fish freezing operation with particular regard to scale.

1.4 The study begins by considering some general aspects of investment in fisheries development. This is followed by an assessment of recent trends in production and trade in frozen foods and frozen fish products (Section 2). An outline description of the freezing process and its appropriate application to fish and crustaceans forms the next section (Section 3) and the report concludes with a description and evaluation of a series of cost models of small-scale freezing plants (Sections 4 and 5).

GENERAL ASPECTS

1.5 Before examining in detail the various investment possibilities considered in this study, planners and analysts should be aware of certain important characteristics of the fisheries sector as a whole which make careful consideration and objective appraisal of such projects particularly important.

1.6 Firstly, 'the fish harvest' is heavily dependent upon the weather and secondly, the relation between the effort that is expended in gathering fish and the actual yield is extremely tenuous. Being a naturally occurring 'free' resource, there is no certain and definable relationship between the catching effort and the amount of fish that is landed. Gluts and periods of shortage are common, often as a result of, or compounded by, seasonal influences, which lead to wide fluctuations in the effective use that is made of catching equipment and processing plant.

1.7 Processing units are of necessity frequently located adjacent to fish landings, which in the tropics are often recognised as in need of infrastructural development. Fishing communities, on the other hand, are commonly highly structured and the social effects of introducing a major processing facility representing a wholly new market outlet that may impinge considerably on traditional roles and patterns of activity within such a community have to be taken into consideration at the planning stage.

1.8 With the exception of fish farming enterprises where the culture and cropping of fish can be strictly controlled, actual catches landed naturally depend to a considerable degree on the extent of fish stocks that exist in the waters to be fished. Over-stimulation of the fishery sector can, however, lead to the diminution of natural stocks to below the level at which such stocks can support a viable fishing industry. Conversely, insufficient exploitation is a waste of a natural resource which could be contributing to opportunities for employment, dietary enhancement and possible foreign exchange earnings. A balanced national approach is therefore essential in order to derive maximum yields without endangering future viability. Consequently, the cumulative effect of fishery development projects requiring additional fish supplies needs to be evaluated as well as the individual merits of isolated proposals.

1.9 In terms of the product itself, fish spoils extremely quickly once it leaves the water. Fast and efficient handling and marketing is therefore essential to maintain quality and ensure the maximum value of the catch when it is offered for sale. Preserving fish by methods such as freezing is comparatively expensive and, given the other factors already mentioned, it is clear that investment in fisheries development, such as that considered in this report, is nearly always accompanied by high levels of risk. It follows, therefore, that projects in this sector depend more than most upon sustained effective management in order that the anticipated benefits may be realised.

THE CASE FOR FISH FREEZING

1.10 The expansion of a fishing industry necessitates the development of processing facilities owing to the perishable nature of the product, although the method of processing chosen will clearly depend on local circumstances. Freezing, coupled with refrigerated transport and a network of cold stores, enables fish to be distributed to areas of a country beyond the reach of fresh supplies. A freezing capability also offers the prospect of tapping export markets and can be used, in conjunction with cold storage facilities, to provide an even flow and mix of species for domestic and export markets. As a result of these potential benefits many developing countries have established fish freezing and storage facilities in recent years.

1.11 Worldwide, frozen fish production has increased very significantly since the early 1960s. Taking 1961/1965 as a base (100), the index of frozen fish production had risen to 268 by 1976, representing a total live weight equivalent of over 13 million tonnes. Further details of production and trade are presented in Section 2.

1.12 Looking to the future, the general movement towards more capital intensive and technologically based fish processing, handling and distribution systems in the developing world is gaining pace. With the running down of resources in many waters of the world that have been the traditional fishing grounds of fleets from the developed world, coupled with the now almost universal acceptance of extended national fishing limits, many maritime countries in tropical areas have a unique opportunity to develop their fishery industries by introducing or extending freezing facilities. Demand from the world's leading importers for most established frozen fish products is generally buoyant, and both the ranks of importers and the range of acceptable traded fish species are currently showing considerable expansion.

Section 2

Trends in production and trade

FROZEN FOODS AND THE CONSUMER

2.1 Since the early 1960s one section of the food market has far outpaced all others in terms of growth in the developed economies of Western Europe and North America, namely frozen foods. For example, in Europe the last decade was marked by a rapid expansion in the distribution of frozen food storage and display facilities amongst food retailers. It is estimated that over 80 per cent of food retailers now have such facilities compared to approximately 38 per cent in 1968. Once the consumer has purchased an item of frozen food, unless it is for immediate consumption, a place is needed to store it, and the increase in retail storage and display facilities was matched by a similar expansion in the number of domestic freezers. In 1968 only about 1 per cent of households in the UK had a freezer, but this figure has now risen to over 30 per cent and is expected to reach 50 per cent in 1980.

TRENDS IN THE CONSUMPTION OF FROZEN FOODS

2.2 Table 1 shows recent total and *per capita* figures for annual consumption of frozen foods in all the major European markets and in the USA. It can be seen that for every country except the UK both total consumption and consumption per head have shown a rising trend. However, none of the individual countries shown have yet reached *per capita* levels remotely comparable to those currently prevailing in the USA. The latter country is not necessarily an appropriate criterion for measuring potential European consumption but the scale of the difference suggests that there is ample scope for expansion. A recent forecast estimated likely consumption levels in 1980, the details of which are presented in Table 2. Comparing the projected 1980 figures in Table 2 with the levels achieved in 1976 it is evident that the demand for frozen food is expected to remain buoyant.

2.3 Looking more specifically at demand trends for fish, Table 3 shows actual demand in 1970 and projected demand for the year 2000. It can be seen from this Table that in 1973 demand for fish and fish products was projected to increase significantly in all parts of the world to the end of this century. Simply to meet the forecast made for 1980, the projections implied that over 100 million tonnes of fish would be required for direct human consumption. Subsequent forecasts (Fisheries Circular No. 343, FAO) suggest that a figure of 110 million tonnes a year by the year 2000 is likely. This represents an expansion of at least 50 per cent on 1978 production levels.

2.4 It has been estimated that each year around 5 million tonnes of fish are discarded as unwanted or unprofitable after being caught, with a similar quantity lost due to spoilage (autolysis, bacterial action, oxidation and insect or vermin

Table 1

Consumption of frozen foods in selected countries, 1975–1977

	1975		1976		1977	
	'000 tonnes	kg/capita	'000 tonnes	kg/capita	'000 tonnes	kg/capita
EEC – the Nine						
France	210.0	4.3	240.0	4.5	290.0	5.4
West Germany	320.3	5.2	344.9	5.6	N/A	N/A
Italy	75.0	1.3	103.0	1.8	123.0	2.2
Belgium/ Luxembourg	50.3	4.9	57.5	5.6	63.5	6.3
Netherlands	118.9	8.7	124.7	9.1	133.8	9.7
Denmark	59.9	11.7	68.2	13.3	70.0	13.7
Eire	9.6	3.1	11.1	3.5	11.7	3.7
UK	747.0	13.4	764.0	13.7	731.0	13.1
Other Countries						
USA	7 121.6	33.3	7 527.6	35.0	N/A	N/A
Switzerland	46.6	7.3	47.7	7.5	52.7	8.4
Austria	30.5	4.0	41.9	5.6	45.6	6.1
Finland	25.5	5.5	29.0	6.1	28.5	6.0
Sweden	139.6	17.0	155.4	18.7	155.4	18.7
Norway	40.4	10.0	43.7	10.8	N/A	N/A

Source: Birds Eye Foods Ltd

Note: N/A = not available

Table 2

Projected per capita frozen food consumption in selected countries, 1980

Country	Projected consumption in 1980 (kg/capita)	Index of consumption (1970 = 100)
France	7.60	415
West Germany	25.50	254
Italy	4.54	757
Belgium/Luxembourg	6.95	320
Netherlands	17.28	266
Denmark	25.10	248
UK	14.07	228
USA	50.5	154
Switzerland	18.45	186
Finland	11.20	280
Sweden	33.30	211
Norway	17.95	264

Source: IRVAM. World Products Forecast, P-1
(Predicasts, 11001 Cedar Avenue, Cleveland, Ohio, 44106)

Table 3

Actual and projected per capita consumption of fish (kg)

	Actual 1970	Projected 1980	2000
World	11.8	13.3	16.2
Developed countries	23.5	26.5	28.7
North America	15.4	16.7	17.7
Western Europe	20.3	24.0	26.6
Oceania	12.4	13.6	15.2
Others	47.5	51.4	54.7
Less developed countries	7.4	8.7	11.7
Africa	7.1	8.7	9.3
Latin America	6.5	7.6	9.2
Near East	2.4	3.0	3.5
Asia	8.5	10.0	14.8
Centrally planned countries	11.3	13.3	18.7
Asia	8.1	9.5	14.8
USSR	23.9	29.7	37.9
Eastern Europe	8.7	10.6	13.1

Source: M. A. Robinson, **Determinants of demand for fish and their effects upon resources,** Technical Conference on Fishery Management and Development, Vancouver, 1973.

attack). If losses could be reduced and markets found for unwanted and unprofitable fish this would significantly increase supplies. Even so the world's fish catching, processing and storage capabilities and capacities would still have to develop enormously to keep pace with anticipated growth. It is in the area of freezing that an increasing contribution to the anticipated requirements is likely to come. Over the past 15 years or so, the trend towards the freezing of fish has already become apparent as shown in Table 4. The growth in the frozen fish sector has been considerably more marked than in any other in terms of quantity processed and the proportion of total demand accounted for by frozen fish has more than doubled over the period shown, growing from 11.2 per cent in 1960 to 26.2 per cent in 1976.

Table 4

Global direct human consumption of fish by type of product

	1960		1970		1975		1976	
Type of product	million tonnes	%	million tonnes	%	million tonnes	%	million tonnes	%
Fresh	16.7	53.2	19.5	44.8	19.0	28.8	19.5	38.3
Frozen	3.5	11.2	9.7	22.3	12.1	24.7	13.3	26.2
Cured	7.5	23.8	8.1	18.6	8.4	17.1	8.3	16.3
Canned	3.7	11.8	6.2	14.3	9.5	19.4	9.8	19.2
TOTAL:	31.4	100.0	43.5	100.0	49.0	100.0	50.9	100.0

Source: *Yearbook of Fisheries Statistics.* Vols 23, 37 and 43. FAO, Rome.

TRENDS IN THE TRADE OF FISH AND FROZEN FISH PRODUCTS

2.5 With regard to trade, Tables 5 and 6 show the quantity and value of world exports of fish and fishery products between 1967 and 1976. In general, trade in food fish products has been remarkably stable over the period shown, but exports of miscellaneous frozen fish increased from 520 000 tonnes in 1967 to 1 365 000

tonnes in 1976. The total value of fish in this category has increased over this same period from US$181 million to US$877 million.

2.6 Although this trade category includes some tuna destined for canning and certain other high value products, including prawns, the principal item in volume terms has recently emerged as frozen pelagic and demersal fish. Major exporters include Poland, the USSR, Japan, Bulgaria and Spain. Significantly, however, these countries have been joined in recent years by others new to the trade such as Senegal, Argentina, Mauritania, Peru, Cuba and The Gambia.

2.7 One major new market for frozen fish that has emerged over the past 15 years or so is West Africa, particularly Nigeria and the Ivory Coast. In 1974 imports of frozen fish into these two countries alone exceeded 190 000 tonnes. Imports to this region have become possible through increasing fish landings and the establishment of necessary associated cold store chains in the various individual countries. These generally consist of large capacity cold stores on the coast supplying small depots spread throughout the country. Further development of cold chains is continuing in this part of the world.

Table 5

Volume of world exports of fish and fishery products, 1967–1976 ('000 tonnes)

Year	Total[1]	Food[2] fish	Frozen fillets	Miscellaneous frozen	Cured fish	Canned fish
1967	7 055	3 229	272	520	515	481
1968	7 692	3 318	327	552	482	521
1969	7 093	3 350	390	549	484	519
1970	7 308	3 669	434	600	501	536
1971	7 618	3 875	399	681	489	528
1972	8 082	4 324	393	764	521	577
1973	6 894	4 711	383	1 057	502	618
1974	7 085	4 567	315	1 122	429	607
1975	7 687	4 873	383	1 313	425	593
1976	7 967	5 259	459	1 365	459	593

Source: 1967–1970, *Yearbook of Fishery Statistics,* Vol 35, FAO, Rome.
1971–1976, *Yearbook of Fishery Statistics,* Vol 43, FAO, Rome.

Notes
1: Incorporating food fish, fish oils and fish meals.
2: All food fish categories incorporating frozen fillets, miscellaneous frozen, cured and canned fish.

2.8 Similar developments are taking place elsewhere in the world and one of the principal aims of this report is to indicate the order of magnitude of the costs involved in establishing small-scale fish freezing plants in order to identify whether at least a proportion of an individual country's market requirement can be produced locally from indigenous supplies of fresh fish at a competitive price. It may also be that certain species are available which could command high prices on the world market so that, with the construction of small freezing and cold storage plants, additional potential revenue could be earned from exports. For example, crustaceans already provide the basis of profitable export-orientated fish processing operations throughout the developing world.

Table 6

Value of world exports of fish and fishery products, (1967–1976) ($US Million)

Year	Total[1]	Food[2] fish	Frozen fillets	Miscellaneous frozen	Cured fish	Canned fish
1967	2 114	1 650	145	181	236	353
1968	2 226	1 764	170	192	221	373
1969	2 441	1 963	214	214	236	378
1970	2 878	2 259	276	231	269	413
1971	3 392	2 738	319	271	308	434
1972	4 114	3 495	364	384	382	529
1973	5 542	4 736	470	620	509	687
1974	5 978	4 980	440	636	579	768
1975	6 217	5 476	498	771	589	734
1976	7 470	6 607	699	877	723	870

Source: 1967–1970, *Yearbook of Fishery Statistics,* Vol 35, FAO, Rome.
1971–1976, *Yearbook of Fishery Statistics,* Vol 43, FAO, Rome.

Notes
1: See note 1, Table 5
2: See note 2, Table 5

Section 3

An outline of freezing in fisheries

REASONS FOR FREEZING FISH

3.1 Fish is frozen in order to slow down and even, in some circumstances, arrest spoilage by inhibiting self-digestion and the action of bacteria. Freezing is, therefore, a means of preparing fish for storage. The effect of the process is to change the water content (generally between 60–80 per cent by weight depending on species) of fish into ice. As a general rule, the quicker fish is frozen, the better the final product. Slow freezing tends to cause large ice crystals to form in the flesh which disrupt the muscle structure and result in substantial 'drip losses' (loss of fluid from the flesh) when the fish is thawed out for consumption or further processing. Slow freezing can also result in the concentration of various salts and enzymes within the body of the fish which can lead to undesirable changes in texture and produce 'off-flavours'.

3.2 The recommended temperature to which fish should be frozen and subsequently stored for long periods is −30°C. Table 7 gives the possible storage life for various species of fish at temperatures down to −30°C. Times shown on this table can be compared with those given in Table 8 which show acceptable storage times for fish in ice at approximately 0°C. The extent to which the storage life of fish can be lengthened by correct freezing and the maintenance of sub-zero temperatures is indicated in Tables 7 and 8.

THE THEORY AND PRACTICE OF FREEZING

3.3 The essential process in freezing food lies in the transfer of heat from the food product to some feature of its surroundings. It is therefore necessary to create a temperature difference sufficiently great, and a means by which heat transfer will take place and continue at the appropriate rate until the product has reached the desired temperature, usually −30°C. Three general methods, contact freezing, blast freezing and immersion freezing are well established, with the first two the most common. A fourth method, involving the use of freon or liquid nitrogen, is a relatively recent innovation and not yet in wide-spread use. Of all these, the oldest method is immersion freezing, traditionally using refrigerated brine, but this is now little used in the fish processing industry except for freezing tuna intended for subsequent canning and sometimes for prawns. The most common methods used are contact and blast freezing.

3.4 Since in the process of freezing heat is to be transferred from the product to be frozen to some surrounding or adjacent material, it is evident that a sufficiently cold material should be supplied to effect this exchange. This is provided by the operation

Table 7

Storage life of frozen fish at varying temperatures

Type of fish	Storage temperature											
	−9°C		−18°C		−20°C		−23°C		−25°C		−30°C	
	good	inedible	good	inedible	good	inedible	good	inedible	good	inedible	good	inedible
(i) (TRS)												
white fish (gutted)	1 month	4 months			4 months	15 months					8 months	more than 4 years
smoked white fish	1 month	3 months			3½ months	10 months					7 months	1 year
herring (gutted)	1 month	3 months			3 months	6 months					6 months	1½ years
kippers	3 weeks	2 months			2 months	5 months					4½ months	9 months
kippers (vacuum packed)											more than 1 year	
whole cooked lobster											6 months	
cooked lobster meat											3 months	
whole cooked crab							4 months				8 months	
cooked crab meat							3 months				6 months	
mussel meats							3 months				8 months	
(ii) (IIR)												
cod, haddock, etc.			3-5 months						6-8 months		8-10 months	
flatfish			4-6 months						7-10 months			
fatty fish			2-3 months						3-5 months		6 months	
lobster and crab			2 months									
shrimp			6 months									
oysters			2-4 months									
scallops			3-4 months									
clams			3-4 months									

Source: Torry Research Station Advisory Note No. 28.

Table 8

Storage life of fish in ice at 0°C

Fish (Common name)	Length of acceptable storage (days)	Notes
TEMPERATE AND COLD WATER		
Marine		
Cod	12–15	
Haddock	12–15	Most flat fish keep better than round fish
Whiting	9–12	
Hake	8–10	
Redfish	13–15	
Herring	5–6	Fatty fish spoil more quickly than lean
Mackerel	7–9	
Freshwater		
Yellow Walleye (Canadian)	20	Fatty fish spoil more quickly than lean
Whitefish	18	
Trout (Europe)	10	
TROPICAL		
Marine		
Snapper (Brazil)	11–16	N.B. Subtropical water temperature 20°C
Tuna (U.S.A.)	29	
Pomfret, Mackerel, Horse mackerel, Seer fish, Perch (India)	7–45	Acceptable quality based upon trimethylamine values
Synagris japonicus (India)	27	
Bonga, Sea bream, Bumper, Burrito (West Africa)	20 26	
Mixed species (West Africa)	17–20	Acceptable quality based upon total volatile base estimate
Freshwater		
Mrigal carp (India)	35	
Tilapia (East Africa)	28	
Nile perch, Bagrus, Lung fish (East Africa)	20–28	

Source: Disney *et al.*, **Considerations in the use of tropical fish species;** paper read at FAO Conference on Fishery Products, Tokyo, 1973

of a refrigeration plant. Most refrigeration plants operate on a cycle of activities as follows:

(i) a gas is piped into a pump where it is compressed to a higher pressure than that of the surrounding atmosphere, thus causing its temperature to rise;

(ii) this gas is then released into a cooled condenser, wherein, still at the higher pressure, it condenses into a liquid. In so doing, the latent heat of the compressed gas is transferred to the coolant;

(iii) the liquid gas is now passed to an evaporator which is maintained at a lower pressure and which causes it to boil and evaporate once again into a gas. In doing this, it draws heat from its surroundings which are chilled; finally,

(iv) the gas is directed back into the compressor where the cycle starts all over again.

It is evident therefore, that if food is placed in the vicinity of the evaporator then heat will be drawn from it as the liquid gas boils and evaporates. The refrigerant is kept in a closed circuit of pipes and heat is drawn from the food through the pipes in the evaporator section of the plant.

CONTACT OR PLATE FREEZER

3.5 The most effective way by which the cooling process could be conducted in a plate freezer would be if the food to be frozen could be brought into actual contact with the evaporator pipes or coils. This, however, is impractical as long as pipes are used. If a flat surface can be used then contact is more likely to be effectively achieved. In practice, contact is made with the use of hollow metal plates which have the refrigerant flowing through their interior. Food is placed between a pair of such plates so that contact is made on two sides of the food and the product can therefore be frozen quickly and effectively. The plates can be either horizontal or vertical. Commercial horizontal plate freezers contain a battery of up to about 20 plates and, provided the food to be frozen can be packed in such a way as to offer a substantial contact area, these machines are very efficient. The product to be frozen is normally placed in the machine on a tray to ensure that the top surface of the product is not uneven and that the bottom of the tray lies flat on the plate beneath. Horizontal plate freezers can be used for freezing packaged fish fillets, crustaceans in plastic bags or waxed cartons, or uniformly sized small to medium whole fish.

3.6 If a large quantity of whole fish of mixed size is to be frozen in block form then a vertical plate freezer is often more useful. The principle is the same but the plates are arranged vertically and the fish is fed in loose without trays and forms a solid pack through the pressure of its own weight. This type of machine is common when freezing takes place at sea.

THE BLAST FREEZER

3.7 The basic principle of heat transfer from the food to an evaporator described in paragraph 3.4 remains the same in the case of the blast freezer. If food is left in an enclosed area close to, but not touching, an evaporator then heat will flow from the food to the surrounding air and from the air to the evaporator and, given time and consistent temperature gradients between the food, air and evaporator, the food item will ultimately freeze. Air is, however, a poor conductor of heat and therefore, with still air, this process would be extremely slow. However, if the air is made to circulate, then warmed air close to the food can be replaced by cooler air which will then absorb some heat before being replaced itself by more cool air. Similarly, air warmed by the food will be brought into closer contact with the evaporator coils. This is the principle of a blast freezer where air is circulated by means of one or more fans which can blast the air in given directions.

3.8 Commercial blast freezers can be based either on a batch type of operation, where, as in plate freezing, fish is entered on open trays, or they may be based on a continuous process where the trays are placed on trolleys which then pass through a blast tunnel at a given speed. Air blast freezers are most suited to irregularly shaped items and items which are to be individually frozen, but they can even be used to freeze different types of item at the same time. A variant of this method uses conveyor belts which, in some cases, allow air to be directed from below through gaps in the belt. In all applications of air blast freezing care must be taken to ensure that air flows freely over and around all products to be frozen.

3.9 The air blast freezer is thus more flexible than the plate freezer and more useful when a variety of non-regular or non-standardised products are required to be frozen. On the other hand it is more expensive to run since fans are required in addition to the refrigeration plant, and will create additional heat. It is also easier to misuse by over- or under-loading. Air blast freezers also need careful defrosting, and must be watched for possible dehydration effects on the product. Since the air in the machine will also tend to warm up rapidly when not in use this type of freezer is more economical when a continuous flow of products to be frozen can be guaranteed.

CHOOSING A FREEZER

3.10 Great care must be taken in choosing the most appropriate type of freezer. To select the basic type of freezer to be used, a potential plant operator will need to consider data on the precise application for which the unit is to be used. Having selected the type of freezer, the equipment supplier will need to be provided with a great deal of data on the precise application for which the unit is to be used in order to design the most appropriate system. This data will include:

(i) the kind(s) of fish product to be frozen;

(ii) the shape, size and packing material of each product;

(iii) the temperature at which the product(s) will enter the freezer;

(iv) the intended cold storage (final) temperature;

(v) maximum and average daily ambient temperature at the location of the plant;

(vi) space available for the freezer;

(vii) position required for the freezer doors;

(viii) details of available electrical supply;

(ix) availability of maintenance facilities and expertise, and

(x) required output of each type of product per day.

3.11 An appropriate freezer can then be specified by the manufacturer based upon time(s) taken to freeze the product(s). This varies with fish according to whether it is large, small, thick, thin, bony, whole, filleted, packaged or in blocks. Table 9 illustrates the freezing times for certain fish and fish products when different methods of freezing are used.

Table 9

Freezing times for selected fish and fish products

Product	Freezing method	Product initial temperature (°C)	Operating temperature (°C)	Freezing time hrs	mins
Whole cod block 100 mm	vertical plate	5	−40	3	20
Whole round fish 125 mm thick e.g. cod salmon, frozen singly	air blast 5 m/s	5	−35	5	00
Whole herring block 100 mm thick	vertical plate	5	−35	3	20
Whole herring 50 mm thick on metal tray	air blast 4 m/s	5	−35	1	40
Cod fillets laminated block 57 mm thick in waxed carton	horizontal plate	6	−40	1	20
Haddock fillets 50 mm thick on metal tray	air blast 4 m/s	5	−35	2	05
Haddock fillets laminated block 37 mm thick in waxed carton	horizontal plate	5	−40	1	02
Kippers in pairs interleaved pack 57 mm thick in cardboard carton	horizontal plate	5	−40	2	15
Whole lobster 500 g	horizontal plate	8	−40	3	00
Whole lobster 500 g	liquid nitrogen	8	−80	0	12
Scampi meats 18 mm thick	air blast 3 m/s	5	−35	0	26
Shrimp meats	liquid nitrogen spray	6	−80	0	5

Source: *FAO Technical Paper* No. 167, **Freezing in fisheries,** FAO, Rome, 1977.

Section 4

Description of the cost models

SELECTION OF THE MODELS

4.1 The freezing plants under consideration all use currently available items of equipment and therefore the quoted establishment costs, operational requirements and throughput capacities reflect actual anticipated inputs of capital and raw material and outputs of finished product if the plants were to become operational. Clearly, when considering similar models designed for particular locations, local costs of inputs such as labour and power will vary and have to be adjusted accordingly. Local costs used in the basic cost models presented here reflect actual levels currently prevailing in a West African country. All of the included capital costs were those obtaining in December 1979 and have been quoted in the analysis, f.o.b. UK port with a c.i.f. provision at 20 per cent of the capital cost. In addition a 10 per cent allowance is given for installation and commissioning.

4.2 Table 10 provides an outline description of the four models included in this study. Essentially, three products, — raw whole prawns, raw headless prawns and whole fish are considered at output levels ranging from 900 kg/day (225 tonnes/annum) to 13 500 kg/day (3 360 tonnes/annum). Each of the models is designed to receive, hold, freeze, pack and store a particular product or product mix.

Table 10

Outline description of the cost models

Model Number	Product(s) handled	Operating days/annum	Shifts/day	Output/day tonnes	Output/ annum tonnes	Ice plant Output/day tonnes	Capital cost £
Model 1	Prawns	250	2	0.9	225	2.7	96 100[1]
Model 2	Prawns	150	2	1.35	202.5	10	190 098[2]
	Whole fish	250	2	3.36	840	10	
Model 3	Whole fish	250	2	8.96	2 240	20	212 120[3]
Model 4	Whole fish	250	3	13.44	3 360	30	352 290[4]

Notes: 1 Table 12
2 Table 15
3 Table 19
4 Table 22

GENERAL FEATURES OF THE MODELS IN OPERATION

4.3 Detailed descriptions of the capital equipment, the operational requirements and an individual financial analysis for each model are presented in Section 5. There are, however, a number of features common to all the models and these are presented below.

A. Freezers

4.4 Each of the cost models has been designed to produce frozen blocks of prawns or fish. Horizontal plate freezers have been used in all the plants, and capacities and technical details of all the units selected are included in Section 5. However, the reader should note that the choice of freezer will depend on the particular application, and horizontal plate freezers may not always be appropriate. Where there is doubt as to the most suitable type of freezer advice can be obtained from the Tropical Products Institute.

B. Chillrooms and cold stores

4.5 Each plant is equipped with a refrigerated chillroom for storing iced raw material prior to processing and a refrigerated cold store for storage of finished products. The type of facilities that have been costed into the models are of prefabricated modular construction, selected for their high thermal efficiency, flexibility of design, ease of transportation and erection on site. Chillroom capacity in each case allows for the holding of sufficient raw material for up to 10 days' operation of the plant, although normally raw material (particularly prawns) would not be stored for as long as this prior to freezing. The cold stores are designed to hold up to 1 month's output of finished product. In practice the design of cold storage capacity depends on the particular case. Ideally, the final product would not be stored for more than a month but often has to be, due to the problems of assembling sufficient material to make collection attractive. Capacities and technical details are given in Section 5.

C. Ice plants

4.6 A flake ice plant has been included as part of the equipment of each model. Allowances have been included for the construction of insulated ice storage bins. In certain situations around the world where consideration is being given to the establishment of fish freezing plants the inclusion of an ice plant may not be necessary since supplies of ice may already be freely available. The plants illustrated in this study, however, given their comparatively low levels of throughput, are most likely to be suited to those regions where freezing capacity (and hence, most probably, ice) is not available. Ice is absolutely essential to maintain the quality of raw material for freezing, especially where catches are liable to remain at high ambient temperatures on board a fishing vessel for an extended period, or where temperature reduction capabilities of the chill room are insufficient to lower the temperature of the fish from ambient down to 1° C or 2° C above freezing once the catch reaches the freezing plant. The required ratio of ice to product is variable, depending on individual circumstances. In the report it has been assumed that 2 parts ice to 1 part of fish and 3 parts of ice to 1 part of prawn are required to keep the products in good condition through from catching to freezing.

4.7 Flake ice, as opposed to block ice, has been selected for a number of reasons which include:

(i) output of ice commences almost immediately the icemaker is switched on, making the plant more flexible;

(ii) handling is simplified if a flake ice plant is installed on top of an insulated storage bin, since the ice simply drops into the bin and is ready for use;

(iii) there is less chance of damage to the raw material (especially prawns) as individual flakes of ice do not have sharp edges and are lighter than chunks of block ice; and

(iv) whilst the principal advantage of block ice is that it can be transported relatively easily over long distances, the fish freezing plants considered here are intended to be located adjacent to fish landings so that ice produced at the plants can be loaded directly onto the fishing boats.

Details of the actual ice plants selected appear in Section 5 and are described for each individual model.

D. Raw material assembly and product disposal

4.8 In each of the models illustrated the operator of the plant is assumed to act as a principal, buying in raw material for processing and then selling the finished packaged frozen product. This is the general practice for operations of this kind, with the fisherman/supplier being paid for his fish once it is accepted for processing by the plant. In addition the processor is assumed to provide ice to the fishermen, although in practice in some locations this might be available from other sources.

E. Working system

4.9 All four models are assumed to operate an 8-hour shift system of working and Table 10 shows that with the exception of Model 4, 2 shifts are worked each day Model 4 functions for 250 days each year on a 3-shift/day basis. The total number of shifts worked per annum varies from 500 where prawns are processed in Model 1 to 750 for the fish freezing plant illustrated in Model 4. In practice, shift hours worked on the freezing operation in Models 1, 2 and 3 may need extending slightly beyond 8 hours due to the sizing of the freezers. Sufficient slack time in a day exists to allow for this. Model 2 allows for a seasonal pattern of availability of raw material in that the prawn line is shown to be operative for only 150 days per annum. In many fisheries, adequate catches of prawns can only be made during certain times of the year.

If the local supply situation required it, the operation of this line could be concentrated still further by operating, say, a 3-shift system for 100 days, giving the same total number of shifts worked per annum and with little effect on the operational cost structure of the plant as a whole.

Similarly, annual working patterns can be adjusted within the other models.

4.10 The effect of concentrating the number of shifts worked per annum into fewer working days due to seasonal availability of supplies could lead to a reduction in costs per unit of output. The plant could perhaps be shut down during the idle months which would reduce its annual power needs. In the models analysed here, allowance has been made for keeping the chill rooms and cold stores functioning throughout the year.

F. Loan and replacement of fish boxes

4.11 Each plant is furnished with a stock of high density polyethylene stack/nest fish boxes appropriate to the throughput and storage capacity of the plant in question. The initial cost of these boxes has been included in the capital cost of each plant. It has been assumed that they would be hired out to the local fishermen for the storage and carriage of their fish, and that the rental fee charged would be sufficient to replace damaged and lost boxes over the period of operation of the plant. Hence, an annual sum for box replacement has not been included in the operating costs. The details of the number and cost of boxes for each plant appear in Section 5.

G. Utilisation of ice

4.12 As has been mentioned above, the models incorporate ice plants. The minimum output of flake ice required is 2.7 tonnes/day in Model 1. For Model 2, the maximum ice requirement is when prawns and fish are being processed simultaneously, when 10 tonnes/day are required. To process the products of Model 3 an ice plant of 20 tonnes/day is required and one of 30 tonnes/day for Model 4. In the financial analysis it is assumed that the ice is provided to fishermen to assure good quality raw material at factory intake. Ice is also assumed to be used throughout the processing operation, including re-icing during preparation, and for cooling processing water. In practice ice could be sold to fishermen or they might purchase ice from independent factories. The effect of either of the latter two assumptions would be to reduce ice plant capacity requirements and establishment and processing costs.

H. Product flows

4.13 The basic stages in the flow of fish through the freezing plants are the same for Models 2, 3 and 4. The prawn line is identical in Models 1 and 2. Figure 1 shows the flow sequence for fish.

(a) Fish

4.14 In the processing plant ice may be required once the fish has been accepted for freezing should any delays occur before the fish is placed in the chill room. Its use is essential to lower the temperature of fish that is to be placed in a chillroom designed to maintain the temperature of a fixed quantity of material rather than reducing it from ambient to just above freezing. In addition, ice will almost certainly be required to cool the water used in processing. Fish that is rejected on size, quality, species or other grounds may be suitable for one or other of the uses suggested in Figure 1. This particular study is concerned solely with an analysis of the freezing process, but the Tropical Products Institute could advise separately on alternative methods of processing rejected or waste material which could be used to further enhance the financial return of the processing plant. It is recommended that acceptable fish should be tallied and paid for immediately on reception. This is a show of good faith to fishermen and will help to ensure regular supplies of good quality raw material. Adequate working capital has been allowed for in the cost models to enable this to be done. Having been washed, sorted, iced and boxed the fish is then placed in the chill room prior to freezing.

4.15 When moved to the freezing line, the fish is packed into freezer trays. Two sets of trays have been supplied for each freezer so that the next charge can be prepared whilst one is being frozen. Depending upon market requirements, the trays may be topped up with water before freezing in order to give good contact with the plates, eliminate air and achieve a uniform rectangular frozen block. If this is not done, it may be necessary to glaze the blocks of frozen fish prior to packaging and storing in order to maximise quality, although glazing is not essential if the packaging is water-impermeable. Glazing can be simply done by dipping the blocks in chilled water as soon as they are freed from the trays. Funds for glazing tanks and other incidental production line items have been included in the capital cost of each model. Packaging consists of wrapping each block in a polythene sheet or bag, placing the blocks in waxed board cartons and strapping and stapling them. The finished product is then ready to be placed in the cold store for eventual sale and despatch.

(b) Prawns

4.16 In the case of prawns, the main elements of the processing are the same as for fish; the flow sequence is as shown in Figure 2. If there is a problem with black spot, which can occur in iced prawns if they are not frozen within a few days of capture, it may be necessary to dip the raw material in a solution of metabisulphite as soon as possible after catching, generally on the vessel. It is imperative to keep the raw material well iced at all times.

4.17 From the chill room prawns are moved on to the preparation stage where grading and sorting takes place. Depending upon the finished product required, beheading and/or peeling would then take place. In certain circumstances, this could be followed by dipping the product in a chlorine solution immediately prior to freezing in order to reduce any bacterial contamination picked up during handling. Chlorine dipping, however, renders the product unacceptable on certain markets and careful hygiene control elsewhere in the process may make this dip unnecessary. Great care must be taken, in any case, to minimise residues.

4.18 Prawns are generally weighed into cartons before freezing, then the filled cartons are arranged on the freezer trays. As with fish, it may be a customer requirement that the cartons are topped up with water at this stage so that the final product emerges as a complete frozen block. Once frozen, the cartons are packed into outers and taken straight into the cold store to await despatch.

I. Production line losses

4.19 Losses of 5 per cent on the prawn lines and 2 per cent on the fish lines have been allowed for in all models.

J. Finished product

4.20 The final packaged product of all the fish freezing processing lines is a stapled and strapped waxed board outer containing 3 x 10 kg polythene-wrapped blocks of whole fish. In the case of prawns the freezers are designed to take waxed card cartons each containing 2 kg of prawns. The cartons are then packed in strapped and stapled board outers each containing 10 cartons.

Figure 1

Product Flow for Fish Processing

Fish arrives at plant in boxes
↓
1. Inspection → REJECT: return to supplier or buy, hold and sell or possible silage or possible fishmeal or destroy.
↓
2. ACCEPT for freezing
↓
3. Weigh (tally and pay supplier)
↓
4. Wash and sort and add ice
↓
5. Box
↓
6. Into chillroom
↓
7. To freezing line
↓
8. Fish into trays, weighed and water added
↓
9. Trays into freezer
↓
10. Freeze
↓
11. Remove trays from freezer
↓
12. Knock out blocks from trays
↓
13. (Glaze blocks – optional)
↓
14. Polythene-wrap blocks, into carton, strap and staple
↓
15. Into cold store
↓
16. Despatch

1–6. RECEPTION
7–13. PROCESSING
14–16. PACK, STORE, DESPATCH.

Figure 2

Product Flow for Prawn Processing

Prawns arrive at Plant in Boxes

↓

1. Inspection → REJECT: return to supplier or buy, hold and sell or possible fishmeal or dry for fertiliser or destroy.

↓

2. ACCEPT for freezing

↓

3. Weigh (tally and pay supplier)

↓

4. Wash and preliminary sorting

↓

5. Box

↓

6. Into chillroom

↓

7. To preparation line

↓

8. Sort (head off/peel)

↓

(8a.) (Chlorine dip – optional)

↓

9. To freezing line

↓

10. Weigh and fill cartons

↓

11. Into trays (add water – close cartons)

↓

12. Freeze

↓

13. Remove trays from freezer

↓

14. Knock out cartons from trays

↓

15. Cartons into outers

↓

16. Into cold store

↓

17. Despatch

1–6. RECEPTION
7–8. PREPARATION
9–14. FREEZE
15–17. PACK, STORE, DESPATCH.

Section 5

Financial analysis of the models

AIMS OF THE FINANCIAL ANALYSIS

5.1 A fish and/or prawn freezing plant requires that the following elements be made available for its establishment and operation:

(i) a suitable site;
(ii) a satisfactory labour force;
(iii) managerial and technical expertise;
(iv) available adequate electrical power or the capability to generate it;
(v) water for cooling, washing, cleaning and ice production;
(vi) appropriate items of capital equipment;
(vii) an accessible market for the finished product, and
(viii) a source of raw material at an appropriate price.

Given all of these elements it is possible to design a suitable operation for a given location in terms of the throughput of the enterprise (depending upon raw material(s) availability) and size of the market for the finished product(s).

5.2 By applying financial values to each element in the design, a net cash flow can be calculated showing the balance between capital and operating costs of the operation (cash outflows) and the revenue obtained from product sales (cash inflows) for each year of the anticipated life of the project. A number of tools are at the disposal of the analyst whereby net cash flows can be used to show the economic and/or financial viability of the plant or to compare its viability with other possible uses of the available capital. The most common financial yardstick used for this comparison is the Internal Rate of Return (IRR). The usual procedure is to compute a value for each individual element of the cash inflows and outflows and then to derive the IRR as a measure of project viability. However, when appraising fish processing projects it is often difficult to predetermine a relevant single price to be paid to fishermen for their catch, particularly in the context of a generalised situation as represented in this report. Prices paid at landings to fishermen in most countries fluctuate not only with location but also from day to day, depending on the size of the catch and the availability of individual species. It is clear, therefore, that in many parts of the world it would be an extremely difficult task, and a process fraught with uncertainty, to predetermine a raw material purchase price from historic data upon which to base the cost structure of a proposed fish freezing project.

5.3 With this problem in mind the approach used in this study has been to assume a required Internal Rate of Return (IRR) for the project models and to then compute the price which, if paid for raw material, would achieve this IRR. This can be done if all other costs, plus the value of the end product, are known. Although the latter presents some problems, it is far easier to predetermine than a raw material price since, to be competitive, the end product price must relate to similar alternative foods in the domestic market or international prices on export markets.

5.4 The financial requirements imposed upon the four models in a sensitivity analysis are that each plant should show an IRR of:

(i) 10 per cent; or

(ii) 20 per cent.

In other words, annual amounts of money available for purchasing raw material have been derived for each model which, when incorporated into the annual cash flows and discounted at 10 per cent or 20 per cent over the working life of the plant result in a zero Net Present Value (NPV). The method used in this analysis is described in detail in Appendix 2. A 10 per cent discount rate has been applied since this corresponds to the test discount rate adopted by the Overseas Development Administration (UK) in project appraisal. A 20 per cent rate has also been included both as a comparison and because it is highly unlikely that commercial capital would be attracted to the enterprise if the IRR was less than 20 per cent.

5.5 From the total annual amount of money that is shown to be available to purchase raw material, a unit purchase price per tonne or per kilogram can be simply calculated by dividing this total by the annual raw material requirements of the plant. This method requires that the value of working capital be known. This is partially dependent on the price of the raw material itself. This problem could be solved by iteration. However, an assessment in the cost models has indicated that an adequate approximation for purposes of analysis is obtained by taking the value of working capital as 25 per cent of the annual operating costs, net of raw material costs, since, once the plant is in full operation, sales of end products are regular, usually at least monthly, and generate sufficient funds for the direct purchase of future raw material requirements.

5.6 In addition to showing the effect of raising the IRR requirements from 10 per cent to 20 per cent, the results of certain variations in other operating costs have also been investigated. The following sensitivity analyses have been undertaken:

(i) Model 1 – reduction by one third of labour costs, the major annual charge on the operational budget of the plant;

(ii) Model 2 – raising and lowering total operating costs by 15 per cent; and

(iii) Models 3 and 4 – raising and lowering electricity charges by 50 per cent.

Models 3 and 4 are the only two that are directly comparable since they both process only whole fish. Consequently, the same sensitivity analysis has been undertaken for both. For each of these models, the cost of electricity is the principal item of expenditure each year (other than the purchase of raw material). A 50 per cent variation in this factor represents a variation of between 18–20 per cent in the total annual operating costs.

Appendix 2 shows, with an example, the method used for the financial analysis and is intended to provide the user with a methodology appropriate for use with the cost structure and factor costs for his own particular situation.

FINISHED PRODUCT PRICES

5.7 A range of finished product prices has been applied in the analysis of each model in conjunction with the various sensitivity analyses presented above. These prices have been selected as being representative of current market levels for appropriate products and are shown in Table 11.

Table 11

Imputed ex-plant prices of frozen prawn products and fish blocks used in the models

Prawns	£1.00/kg
	£2.00/kg
	£3.00/kg
	£4.00/kg
Fish (Blocks)	£150/tonne
	£200/tonne
	£250/tonne

ANALYSIS OF THE MODELS

A. Model 1

5.8 Model 1 is designed to freeze prawns and has a daily output of 900 kg. of finished product based on 2-shift per day operation. Chill storage capacity at reception amounts to 10 tonnes whilst cold storage for the final frozen product is sufficient for 20 tonnes. A small flake ice plant is included, with an output of 2.7 tonnes per 24 hours. It is envisaged that a small plant such as this, based on a horizontal plate freezer selected from a range of commercially available units covering one of the lowest charge levels available, could prove to be an appropriate initial investment in the application of freezing methods as a means of preserving crustacea in a suitable area. It might be located in a region where a small-scale active artisanal fishery is already landing prawns for local fresh retail or catering consumption, or where as yet an unexploited adequate resource has been identified that could be exploited by the existing fishing community.

5.9 Clearly access to a port or to an established cold store system would greatly widen the market possibilities and it would seem likely that in most situations the availability of frozen shipping space, and hence export markets, would be the major justification for setting up the plant. Cold storage capacity at the plant is sufficient for more than 20 days full production to be held at any one time. This allows for considerable flexibility in despatching the finished product to a port without cold storage facilities of its own, for shipment overseas as and when frozen cargo space becomes available.

5.10 The prawn freezing plant operators consulted during the preparation of this study recommend that, assuming the constraints of the market allow it, initial production should concentrate on whole raw or headless raw crustacea. Hence, the envisaged output of prawns of Models 1 (and 2) is a raw product. In addition, analysis of the comparative cost implications of producing a whole and headless raw product have been investigated.

5.11 Details of individual items of capital equipment for Model 1 are given in Table 12. Total capital costs are estimated at approximately £96,000. During the 15 years life of the project, capital costs occur as follows:

Year	*Item*	*£ Net cost*
0	Initial capital cost of plant	96 100
5	Pick-up truck replacement plus 20 per cent c.i.f.	6 600
8	Replacement of freezer and ice plant plus 20 per cent c.i.f	22 440
10	Pick-up truck replacement + 20 per cent c.i.f.	6 600

5.12 Table 13 shows the annual operating costs for Model 1, these amount to some £66,650 per annum.

Table 12

Capital costs of Model 1

Item		£
1. Building		15 000
2. Plate freezer		9 900
3. Chill room		4 400
4. Cold store		7 800
5. Freezer trays		1 300
6. Fish boxes		2 750
7. Ice plant		8 800
8. Ice storage bin		2 200
9. Standby generator		6 215
10. Weighing machine		300
11. Work tables		2 000
12. Steam cleaner		1 300
13. Production line items		2 200
14. Office equipment, clothing etc.		2 200
15. Pick-up truck		5 500
	Total items 2 – 15	56 856
	Total	71 865
	10 per cent contingency	7 185
	Total	79 050
	c.i.f. at 20 per cent, items 2 – 15	11 370
	10 per cent installation and commissioning on items 2 – 15	5 680
	Grand total	96 100

Notes:
1. 250 m^2 @ £60/m^2
2. 4 station mini-freezer; total charge 180 kg; 5 charges/day
3. 10 tonne capacity, temperature range –1°C to + 1°C
4. 20 tonne capacity, design temperature –30°C
5. 30 x 2
6. 500
7. 2.7 tonnes/24 hrs.
8. Local construction
9. 70 KVA
10. 100 kg flat bed
11. 6 of each; stainless steel top, wooden supports
12. One, with water input, diesel powered

Table 13

Operating costs of Model 1

Item	£
1. Labour	37 200
2. Power	12 500
3. Packaging	13 250
4. Water	250
5. Insurance, spares, maintenance, repairs.	3 450
Total	66 650

Notes
1. See Appendix 1.
2. 250,000 KWH @ 5p per unit.
3. 450 per day, 2 kg inners, plus 45 per day of 20 kg outers
4. 1000 tonnes @ 25p per 1000 litres.

5.13 It can be seen that for Model 1 the cost of labour is by far the most important annual charge and is therefore the factor to which any sensitivity analysis should be applied. In certain parts of the world labour rates may well be considerably lower

than those used in this model, and thus an additional calculation has been made with the annual cost of labour reduced by one third. The difference between these two estimates represents approximately a 20 per cent reduction in total operating costs. Thus, in any actual situation where an overall reduction in operating costs of this order can be obtained, the calculation based on the lower labour charge presented here would apply.

5.14 Revenue is calculated on the following assumption that the total annual output of packaged frozen prawn product amounts to (0.9 tonnes x 250 days) = 225 tonnes. A range of ex-plant prices have been assumed giving the following annual revenues:

Ex-plant price £/kg	*Annual revenue* £
1.00	225 000
2.00	450 000
3.00	775 000
4.00	900 000

5.15 On this basis the quantities of raw material required would be as follows:

(i) Production of whole frozen raw prawns:
Allowing for a 5 per cent waste and/or loss, approximately 237 tonnes of raw material are required to sustain an annual output of 225 tonnes of whole frozen prawn; and

(ii) Production of headless or frozen prawns:
Allowing for a headless yield[1] of 60 per cent and an overall waste and/or loss of 5 per cent of total throughput, approximately 394 tonnes of raw material are required to sustain an annual output of 225 tonnes of headless raw frozen prawns.

5.16 Given the costs outlined in Tables 12 and 13 and the anticipated revenue, it is possible to determine the price that the operator of the freezing plant described in Model 1 could afford to pay for raw material based on Internal Rates of Return of 10 per cent and 20 per cent. Table 14 summarises the results, showing annual cash availability together with quantitative requirements for raw material. Given these parameters it is possible to use this Table to derive raw material prices for selected ex-plant prices for end products, assuming an IRR of either 10 per cent or 20 per cent.

5.17 It can be seen from Table 14 that, for example, at an ex-plant price of £4/kg. for raw headless prawns, an operator of the basic cost version of Model 1 could pay £2.05/kg. to a local supplier/fisherman for supplies of wet whole prawns to ensure an IRR within the project as a whole of 20 per cent. Similarly, to show an IRR of 10 per cent, Table 14 shows that a plant operator could pay £0.36/kg. for his raw material if he could sell raw whole prawns at £1/kg. If labour costs are reduced by one third (or total operating costs by 20 per cent) the corresponding landed prices could be increased to £2.08 and £0.39 respectively.

B. Model 2

5.18 Model 2 combines freezing lines for both prawns and whole fish. Although the daily production capacity for frozen crustacea is 50 per cent higher than in Model 1, the annual production is approximately the same. This is because the production of prawns is concentrated into only 150 working days instead of 250 to allow for limited seasonal availability of supplies. This is a common feature of prawn fisheries in many parts of the world. Ice plant has been included in the model to cope with the simultaneous production of prawn and fish products with a 10 tonne/day flake ice plant. The major difference between Model 2 and Model 1, however, is that a fish freezing line has been included, with a daily processing capacity of over 3 tonnes

1 — headless yield is variable depending on the type of prawn; 60 per cent can be considered as an upper limit.

and annual production of 840 tonnes based on 2-shift working for 250 days each year. On its own, a fish freezing plant with such small turnover would be unlikely to prove viable but, in conjunction with efficient processing of crustacea, the combination could prove to be commercially sound. Furthermore, the existence of the fish processing line allows the plant operator to purchase what may in many locations be fish that would be normally discarded by prawn fishermen.

Table 14

Derived raw material prices for the production of frozen prawns, Model 1

	Ex-plant price per kg	Annual cash availability for raw material	Raw whole prawns: Raw material requirement	Raw whole prawns: Derived landed price per kg	Raw headless prawns: Raw material requirement	Raw headless prawns: Derived landed price per kg
	£	£	Tonnes	£	Tonnes	£
TO SHOW AN INTERNAL RATE OF RETURN OF 10%						
A. Basic cost model	1.00	141 750	237	0.60	394	0.36
	2.00	366 750	237	1.55	394	0.93
	3.00	691 750	237	2.92	394	1.76
	4.00	816 750	237	3.45	394	2.07
B. Reduced labour Cost	1.00	154 460	237	0.65	394	0.39
	2.00	379 460	237	1.60	394	0.96
	3.00	704 460	237	2.97	394	1.79
	4.00	829 460	237	3.50	394	2.10
TO SHOW AN INTERNAL RATE OF RETURN OF 20%						
A. Basic cost model	1.00	132 530	237	0.56	394	0.34
	2.00	357 530	237	1.51	394	0.91
	3.00	682 530	237	2.88	394	1.73
	4.00	807 530	237	3.41	394	2.05
B. Reduced labour Cost	1.00	145 550	237	0.61	394	0.37
	2.00	370 550	237	1.56	394	0.94
	3.00	695 550	237	2.94	394	1.76
	4.00	820 550	237	3.46	394	2.08

5.19 Details of individual items of capital equipment for Model 2 are given in Table 15 and amount to some £190 000. It is estimated that during the 15 years life of the plant capital costs occur as follows:

Year	*Item*	*£ cost*
0	Initial capital cost of plant	190 098
5	Pick-up truck replacement plus 20 per cent c.i.f.	6 600
8	Replacement of freezers and ice plant plus 20 per cent c.i.f.	56 760
10	Pick-up truck replacement plus 20 per cent c.i.f.	6 600

5.20 The annual operating costs of Model 2 are shown in Table 16.

5.21 In addition to the basic cost Model, the effect of both raising and lowering total operating costs by 15 per cent is investigated.

5.22 The anticipated revenue accruing to this model is calculated on the basis of the following assumptions:

(i) Prawns – the prawn processing line in Model 2 is required to operate for 150 days/annum on a 2-shift/day basis, with a total annual output of 202.5 tonnes. A

Table 15

Capital costs of Model 2

Item:		Cost (£)
1. Building		27 000
Fish:		
2. Freezer		13 200
3. Freezer trays		1 900
4. Working tables		1 650
5. Production line items		2 200
Prawns:		
6. Freezer		11 100
7. Freezer trays		2 000
8. Working tables		2 600
9. Production line items		2 200
General:		
10. Fish boxes		5 500
11. Chill room		7 800
12. Cold store		14 520
13. Standby generator		9 300
14. Weighing machines		600
15. Pick-up truck		5 500
16. Steam cleaner		1 300
17. Office equipment, clothing etc.		2 200
18. Ice plant 10 tonne/24 hour		23 000
19. Ice store		8 000
	Total items 2 – 19	114 570
	Total	141 570
	10 per cent contingency	14 157
	Total	155 727
	c.i.f. at 20 per cent on items 2 – 19	22 914
	10 per cent installation and commissioning on items 2 – 19	11 457
	Grand total	190 098

Notes:
1. 450 m^2 = £60/m^2
2. six station 30 kw freezer, total charge 270 kg; 5 charges/day
3. 42 x 2 @ £20 each
4. 5 @ £300 each
5. –
6. seven station freezer; total charge 420 kg; 8 charges/day
7. 45 x 2
8. 8 with stainless steel tops and wooden supports
9. –
10. 1000
11. 20 tonne capacity design temperature 0°C
12. 50 tonne cold store, 25 tonne sections; temperature –30°C
13. 100 KVA
14. 2 x 100 kg flatbed

Table 16

Operating costs of Model 2

Item	£
1. Labour	41 800
2. Power	36 170
3. Packaging	20 800
4. Water	600
5. Insurance, spares, maintenance, repairs	5 000
Total	104 370

Notes
1. See Appendix 1.
2. 723 400 KWH's @ 5p per unit.
3. 84 000 of 10 kg
   28 000 of 30 kg
   10 125 outers for prawns
   101 250 inners for prawns
4. 2 400 cubic metres.

range of ex-plant prices for the finished product has been considered giving the following yearly revenues:

Ex-plant price £/kg	*Annual revenue £*
1.0	202 500
2.0	405 000
3.0	607 000

(ii) Fish – fish block production is based on 250 days x 2 shifts per day giving an annual output of 840 tonnes. Revenues generated by sales at the ex-plant prices under consideration are as follows:

Ex-plant price £/kg	*Annual revenue £*
150	126 000
200	168 000
250	210 000

Combining these two sets of figures results in the range of anticipated annual revenues given in Table 17.

Table 17

Range of anticipated revenues – Model 2

Ex-plant prices		
Prawns £/kg	Fish £/tonne	Total annual revenue (£)
1.00	150	328 500
1.00	250	412 500
2.00	250	615 000
3.00	150	733 500
3.00	200	775 500
3.00	250	817 500

5.23 The quantities of raw materials required by this plant are estimated to be as follows:

(i) Prawns (Raw)
(a) Whole – allowing for 5 per cent waste and/or loss, approximately 213 tonnes of raw material is required to sustain an annual output of 202.5 tonnes of packaged whole frozen prawns; and

(b) Headless – allowing for a headless yield of 60 per cent, and an overall waste and/or loss of 5 per cent, approximately 355 tonnes of raw material are required to sustain an annual output of 202.5 tonnes of packaged headless raw frozen prawns.

(ii) Fish
Allowing for 2 per cent waste and/or loss, approximately 857 tonnes of wet fish are required to sustain an annual output of 840 tonnes of blocks of frozen whole fish.

5.24 Clearly when considering the possibility of establishing a freezing plant based on the lines of Model 2, a planner or potential operator would need to know the approximate price at which adequate supplies of both prawns and fish could be assured. In order to keep the derivation of raw material prices as simple as possible it is assumed that the entrepreneur already has some experience of freezing prawns along the lines outlined for Model 1. Therefore, using producer (raw material) prices that have been derived for the basic cost version of Model 1, (Table 14) which has an annual prawn output similar to that of Model 2 (225 tonnes compared to 202.5 tonnes), derived raw material prices for fish in the Model 2 situation are

easily determined. For example, Table 14 showed that to ensure that the plant would show an IRR of 20 per cent, the operator of Model 1 could pay a supplier 1.51/kg for prawns if the final product of the plant were frozen whole prawns that could be sold ex-plant for £2/kg (£2 000/tonne). The raw material requirement for Model 2 (for the production of whole frozen prawns) is 213 tonnes, which at £1.51/kg (£1 510/tonne) amounts to a cost of £321 630 per annum. Assuming that sales of fish can be made ex-plant at £250/tonne, Table 18 shows that the balance available for the purchase of wet fish is £461 170 – £321 630 = £139 540. Model 2 required 857 tonnes of wet fish per annum; thus the raw material price for fish is £139 540 ÷ 857 = £162.82/tonne.

5.25 Table 18 shows the amount of cash that an operator of Model 2 would have available for the purchase of raw materials, given a range of ex-plant prices of between £150/tonne and £250/tonne for fish and £1 000/tonne and £3 000/tonne for prawns, assuming that the plant is required to show an IRR of 10 per cent or 20 per cent.

C. Model 3

5.26 This model assumes a basic fish freezing plant with an output of 2 240 tonnes of blocks of whole frozen fish per annum, combined with an ice plant producing up to 20 tonnes of flake ice per day (2 x 10 tonne units). The model allows for full operation over 250 days each year based on 2-shift per day working. Although local raw material and operating costs will vary considerably from place to place and from country to country, it would seem unlikely that there are many locations able to support a commercially viable fish freezing plant with an output much below that of Model 3. It should be borne in mind, however, that the development of fish freezing facilities coupled with access to export markets can result in prices far higher than those prevailing in localised domestic markets becoming attainable for particular species. This possibility should therefore be high on the list of considerations investigated by planners with funds available to cover the establishment of plant such as this, even if at first sight such a project may not appear to be justified based on local wholesale/retail prices for fresh fish.

5.27 Details of the individual items of capital equipment required by Model 3 are given in Table 19 and amount to an initial investment of approximately £272 000. During the 15 years' life of the project capital costs occur as follows:

Year	*Item*	*£ cost*
0	Initial capital cost of the plant.	272 120
5	Pick-up truck replacement plus 20 per cent c.i.f.	6 600
8	Replacement of freezers and ice plant plus 20 per cent c.i.f.	91 200
10	Pick-up truck replacement plus 20 per cent c.i.f.	6 606

5.28 The operating costs of Model 3, amounting to some £124 429 per annum, are summarised in Table 20.

5.29 As the scale of operation increases, power costs, as opposed to labour costs, tend to become the most important element in the operational cost structure. In the basic cost model illustrated above, annual charges amount to £50 000 at £0.05 per KWH. This unit price varies widely from country to country, and so an analysis of the effect upon the derived raw material price has been calculated with this charge being raised and lowered by 50 per cent. This effectively alters the total operating costs by £25 000/annum, representing a variatoin of almost exactly 20 per cent in the total.

Table 18

Derived raw material prices for Model 2

Model	Ex-plant fish price £/tonne	Ex-plant prawn price £/tonne	Annual cash[1] available for raw material £	Tonnes raw material[2] for prawn processing: Raw whole (tonnes)	Raw beheaded (tonnes)	Cash available used[3] for prawns: Raw whole TOTAL	Raw whole £/tonne	Raw beheaded TOTAL	Raw beheaded £/tonne	Residual[4] cash for fish £	Tonnes fish	£/tonne[5] for fish raw material
Basic cost model (10% IRR)	150	1 000	192 250	213	–	127 800	600	–	–	64 450	857	75.20
	150	1 000	192 250	–	355	–	–	127 800	360	64 450	857	75.20
	150	3 000	597 250	213	–	621 960	2 920	–	–	24 710	857	NF[6]
	150	3 000	597 250	–	355	–	–	621 960	1 760	24 710	857	NF[6]
	200	3 000	639 250	213	–	621 960	2 920	–	–	17 290	857	20.17
	200	3 000	639 250	–	355	–	–	621 960	1 760	17 290	857	20.17
	250	1 000	276 250	213	–	127 800	600	–	–	148 450	857	173.22
	250	1 000	276 250	–	355	–	–	127 800	360	148 450	857	173.22
	250	2 000	478 750	213	–	330 150	1 550	–	–	148 600	857	173.39
	250	2 000	478 750	–	355	–	–	330 150	930	148 600	857	173.39
	250	3 000	681 250	213	–	621 960	2 920	–	–	59 290	857	69.18
	250	3 000	681 250	–	355	–	–	621 960	1 760	59 290	857	69.18
Basic cost model (20% IRR)	150	1 000	174 670	213	–	119 280	560	–	–	55 390	857	64.63
	150	1 000	174 670	–	355	–	–	119 280	340	55 390	857	64.63
	150	3 000	599 670	213	–	613 440	2 880	–	–	33 770	857	NF[6]
	150	3 000	599 670	–	355	–	–	613 440	1 730	33 770	857	NF[6]
	200	3 000	621 670	213	–	613 440	2 880	–	–	8 230	857	9.60
	200	3 000	621 670	–	355	–	–	613 440	1 730	8 230	857	9.60
	250	1 000	258 670	213	–	119 280	560	–	–	139 390	857	162.65
	250	1 000	258 670	–	355	–	–	119 280	340	139 390	857	162.65
	250	2 000	461 170	213	–	321 630	1 510	–	–	139 540	857	162.82
	250	2 000	461 170	–	355	–	–	321 630	910	139 540	857	162.82
	250	3 000	663 670	213	–	613 440	2 880	–	–	50 230	857	58.61
	250	3 000	663 670	–	355	–	–	613 440	1 730	50 230	857	58.61
Lower cost model (10% IRR) (Operating costs reduced by 15%)	200	3 000	655 300	213	–	621 960	2 920	–	–	33 340	857	38.90
	200	3 000	655 300	–	355	–	–	621 960	1 760	33 340	857	38.90
	250	2 000	494 800	213	–	330 150	1 550	–	–	164 650	857	192.12
	250	2 000	494 800	–	355	–	–	330 150	930	164 650	857	192.12
Lower cost model (20% IRR) (Operating costs reduced by 15%)	200	3 000	638 110	213	–	613 440	2 880	–	–	24 670	857	28.79
	200	3 000	638 110	–	355	–	–	613 440	1 730	24 670	857	28.79
	250	2 000	477 610	213	–	321 630	1 510	–	–	155 980	857	182.00
	250	2 000	477 610	–	355	–	–	321 630	910	155 980	857	182.00
Higher cost model (10% IRR) (Operating costs increased by 15%)	200	3 000	623 200	213	–	621 960	2 920	–	–	8 760	857	10.22
	200	3 000	623 200	–	355	–	–	621 960	1 760	8 760	857	10.22
	250	2 000	462 700	213	–	330 150	1 550	–	–	132 550	857	159.66
	250	2 000	462 700	–	355.	–	–	330 150	930	132 550	857	154.66
Higher cost model (20% IRR) (Operating costs increased by 15%)	200	3 000	605 230	213	–	613 440	2 880	–	–	8 210	857	NF[6]
	200	3 000	605 230	–	355	–	–	613 440	1 730	8 210	857	NF[6]
	250	2 000	444 730	213	–	321 630	1 510	–	–	123 100	857	143.64
	250	2 000	444 730	–	355	–	–	321 630	910	123 100	857	143.64

Notes:
1. For method of derivation see Appendix 2. 2. From paragraph 5.23. 3. Maximum price per tonne for raw material derived from the Model 1 Analysis of Table 14. 4. Annual cash available for the purchase of raw material less cash used for the purchase of raw material for prawn processing. 5. Residual cash available for the purchase of fish – tonnes of raw material required. 6. NF – not feasible – derived fish price negative.

Table 19

Capital cost of Model 3

Item:		*Cost (£)*
1. Building		30 000
2. Plate freezers (2)		30 000
3. Chill room		10 800
4. Cold store		26 500
5. Freezer trays		5 000
6. Fish boxes		13 750
7. Ice plant (2 x 10 tonnes/24 hours)		46 000
8. Ice storage bin		16 000
9. Standby generator		9 300
10. Weighing machines		600
11. Work tables		1 650
12. Steam cleaner		1 300
13. Production line items		2 200
14. Office equipment, clothing etc.		2 200
15. Pick-up truck		5 500
	Total items 2 — 15	170 800
	Total	200 800
	10 per cent contingency	20 080
	Total	220 880
	c.i.f. at 20 per cent on items 2 — 15	34 160
	10 per cent installation and commissioning on items 2 — 15	17 080
	Grand total	272 120

Notes:

1. 500 m^2 @ £60/m^2
2. 2 x seven station freezers: total charge 560 kg; 8 charges/day each
3. 50 tonne capacity; temperature -1°C to $+1^\circ$C
4. 100 tonne capacity; two 50 tonne sections, temperature -30°C
5. 56 per freezer x 2 freezers x 2 sets @ £20 each
6. 2500 @ £5 each
7. 10 tonnes/24 hrs
8. Local construction
9. As per model 2
10. 2 x 100 kg flat bed
11. 5 x £300 each; wooden supports, stainless steel top

Table 20

Operating costs (£): Model 3

1. Labour	40 560
2. Power	50 000
3. Packaging	24 250
4. Water	1 875
5. Insurance, spares, maintenance, repairs	7 744
Total	124 429

5.30 As in the case of the output of frozen fish blocks from Model 2, a range of ex-plant prices has been imputed for Model 3. The range of total annual revenues under consideration here is as follows:

Ex-plant fish price £/tonne	*Annual revenue £*
150	336 000
200	448 000
250	560 000

5.31 As previously described it has been assumed for the purposes of this study that only blocks of frozen whole fish are being produced. Allowing for losses and/or wastage of 2 per cent the plant illustrated in Model 3 would require approximately 2 285 tonnes of wet fish each year for an output of 2 240 tonnes of frozen blocks.

5.32 The range of prices that an operator of Model 3 could afford to pay for raw material (i.e. whole wet fish), given the variations in the assumption imposed upon him that have been outlined above and in order that the operation of the plant can show a return of 10 per cent or 20 per cent, are detailed in Table 21.

Table 21

Derived raw material price for the production of frozen blocks of whole fish, Model 3

	1	2	3	4	5
	Ex-plant price	Annual cash availability for raw material	Raw material requirement	Derived raw material price	Approximate processing cost[1]
	£/tonne	£	tonnes	£/tonne	P/kg
TO SHOW AN IRR OF 10%:					
A. Basic cost model	150	166 320	2 285	72.79	
	200	278 320	2 285	121.80	7.4
	250	390 320	2 285	170.82	
B. Lower power cost (–50%)	150	191 950	2 285	84.00	
	200	303 950	2 285	133.02	6.3
	250	415 950	2 285	182.03	
C. Higher power cost (+50%)	150	140 700	2 285	61.58	
	200	252 700	2 285	110.59	8.5
	250	364 700	2 285	159.61	
TO SHOW AN IRR OF 20%:					
A. Basic cost model	150	141 860	2 285	62.08	
	200	253 860	2 285	111.10	8.5
	250	365 860	2 285	160.11	
B. Lower power cost (–50%)	150	168 110	2 285	73.57	
	200	280 110	2 285	122.59	7.3
	250	392 110	2 285	171.60	
C. Higher power cost (+50%)	150	115 610	2 285	50.60	
	200	227 610	2 285	99.61	9.6
	250	339 610	2 285	143.63	

Note 1: (i) Total processing cost = revenue – annual cash available for raw material.
(ii) Revenue = Column (1) x volume of end product (2 240 tonnes).
(iii) Annual cash available for raw material = column (2).
(iv) Processing cost per unit of raw material =

$$\left(\begin{array}{ll}\text{Total processing cost} \div & \text{volume processed} \\ \text{((i) above)} & \text{(column (3))}\end{array}\right) \times (100/1\,000)^{\text{Note 2}}$$

2: Multiply by 100 to give pence per tonne and divide by 1 000 to give pence per kg.

5.33 Table 21 shows that the derived raw material price payable by the operator of Model 3 varies between £50/tonne and £84/tonne when the ex-plant price is £150/tonne, between £99/tonne and £133/tonne when the ex-plant price is £200/tonne, and between £143/tonne and £182/tonne when the ex-plant price is £250/tonne, depending upon given variations in operating costs (in this case power) and the Internal Rate of Return (IRR) that the plant as a whole is required to show.

The final column in Table 21 shows the approximate processing costs incurred by the plant when incorporating the various assumptions given here, assuming that the plant itself purchases its raw material requirements and sells its output on its own account. It can be seen that the requirement for the plant to show an IRR of 20 per cent as opposed to 10 per cent puts around 1.0–1.1 pence/kg on the processing cost across the range. For the basic model the average processing cost is shown to be 7.4 pence/kg to show a 10 per cent IRR, and 8.5 pence/kg to show an IRR of 20 per cent. A 50 per cent change in power costs also raises or lowers processing costs by approximately 1.1 pence/kg.

D. Model 4

5.34 The processing system in this plant, is similar to that illustrated in Model 3. The principal difference is that it is based on a 3-shift/day operation for 250 days each year rather than 2 shifts as in Model 3. The ice plant has been increased from 20 to 30 tonnes/day and an extra 7 station plate freezer of 280 kg charge has been added. Other increased capital costs are incurred by providing additional fish boxes and freezer trays to cope with the higher throughput. Furthermore, a standby generator has been included, capable of supplying sufficient electrical power to keep the entire plant operational should power cuts occur rather than to keep only the chill room and cold store functioning as in Model 3. Clearly there are additional operational requirements in terms of labour, power, water etc., but there are no significant technical problems involved in up-grading Model 3 to the Model 4 status.

5.35 Given the 50 per cent increase in throughput, however, all of which has to be handled within existing chillroom and cold store capacity, product flow in terms of raw material and processed frozen fish blocks would have to be more tightly controlled, making for a more efficient use of the capital equipment employed in the plant. Clearly, therefore, the up-grading of a Model 3 plant to the level of Model 4 demands:

(i) adequate and regular additional whole wet fish supplies being available; and

(ii) that an increased frequency of finished product (sales) and collection can be assured.

Given that these two fundamental requirements can be met, it could be a logical and practical step for the management of a 2-shift per day plant, having gained sufficient operational experience, to establish a 3-shift/day system.

5.36 There may of course be certain situations where sources of raw material and labour, coupled with greater local/export demand and/or better domestic distribution channels and facilities, would justify the immediate establishment of a plant based on Model 4 rather than Model 3.

5.37 It can be seen from Table 22 that the establishment costs at £352 000 are £80 000 (approximately 30 per cent) higher for Model 4 than for Model 3. During the 15-year life of the project capital costs occur as follows:

Year	*Item*	*£ cost*
0	Initial capital cost of plant.	352 290
5	Pick-up truck replacement plus 20 per cent c.i.f.	6 600
8	Replace ice plant and freezers plus 20 per cent c.i.f.	126 000
10	Pick-up truck replacement plus 20 per cent c.i.f.	6 600

Table 22

Capital costs of Model 4

Item:	*Cost (£)*
1. Building	30 000
2. Plate freezers (3)	45 000
3. Chill room	10 800
4. Cold store	26 500
5. Freezer trays	7 390
6. Fish boxes	20 625
7. Ice plant (30 tonne/day)	
8. Ice storage	90 00
9. Standby generator	14 300
10. Weighing machines	600
11. Work tables	1 650
12. Steam cleaner	1 300
13. Production line items	2 200
14. Office equipment, clothing etc.	2 200
15. Pick-up truck	5 500
Total items 2 – 15	228 065
Total	258 065
10 per cent contingency	25 806
Total	283 871
c.i.f. at 20 per cent on items 2 – 15	45 613
10 per cent installation and commission on items 2 – 15	22 806
Grand total	352 290

Notes:

1. 500 m^2 @ £60/m^2
2. 3 x 7 station plate freezers (of type used in Model 3)
3. as per model 3
4. as per model 3
5. 6 per freezer and 2 freezers x 3 sets
6. 3750
7. 30 tonne/day flake ice plant
8. as per model 3
9. 19 KVA
10. 2 x 100 kg flat bed
11. 5 with stainless steel tops and wooden supports.

5.38 Operating costs incurred annually by model 4, which amount to £164 211 per annum, are shown in Table 23.

As in the case of Model 3, electricity charges are the main element in the annual operating costs and have been costed at £0.05, £0.025 and £0.075/KWH. This represents a variation of plus or minus 18 per cent in the total annual operating costs.

Table 23

Operating costs of Model 4

1. Labour		57 240
2. Power		60 500
3. Packaging		34 730
4. Water		2 500
5. Insurance, spares, maintenance		9 241
	Total	164 211

Notes:
1. See Appendix I
2. 1.21 million KWH at 5p per unit
3. 336 000 inners
   112 000 outers
   plus strapping etc.

5.39 Based on ex-plant prices identical to those for Model 3 the range of imputed annual revenues is as follows:

Ex-plant fish price £/tonne	*Annual revenue £*
150	509 000
200	672 000
250	840 000

5.40 The output of Model 4 is 3 360 tonnes of blocks of frozen whole fish per annum. Allowing for losses and/or wastage of 2 per cent approximately 3 430 tonnes of wet fish would be needed each year to maintain this output. Given the range of annual revenues above, Table 24 shows the range of prices that an operator of Model 4 could pay for raw material, given the assumption outlined and in order that the plant should show a return of 10 per cent or 20 per cent.

5.41 If Model 4 is to achieve an Internal Rate of Return of 10 per cent, Table 24 shows that derived raw material prices for producing fish blocks ex-plant at £200/tonne vary from £122 to £140/tonne given the change from maximum to minimum power costs. Selling at the same ex-factory price, but with the plant required to show an Internal Rate of Return of 20 per cent, an operator would be able to pay from £112 to £131/tonne given the same range of power charges. An increase from 10 per cent to 20 per cent in the IRR requirement of the project would on average reduce payable producer prices by between 5–11 per cent, depending upon the unit value of the end product.

5.42 By comparing Table 24 with Table 21 it can be seen that derived raw material prices that can be paid by an operator of Model 4 are around £9/tonne higher than those that could be paid by an operator of Model 3 when both plants are required to show the same Internal Rate of Return. This reflects the more intensive and more efficient use of employed capital and equipment. The average processing cost in Model 4 is shown to be 6.5 pence/kg to show a 10 per cent IRR and 7.4 pence/kg to show a 20 per cent IRR. A 50 per cent change in power costs raises or lowers the processing costs by some 0.9 pence/kg. The average cost per kg for freezing and packaging whole fish blocks in Model 4, given the range of variables analysed, is 0.9 pence/kg lower than for Model 3, reflecting the more effective spreading of overhead costs resulting from the higher throughput of Model 4.

Table 24

Derived raw material price for the production of frozen blocks of whole fish, Model 4

	1	2	3	4	5
	Ex-plant price	Annual cash availability for raw material	Raw material requirement	Derived raw material price	Approximate processing cost[1]
	£/tonne	£	tonnes	£/tonne	P/kg
TO SHOW AN IRR OF 10%:					
A. Basic cost model	150	280 870	3 430	81.89	
	200	448 870	3 430	130.87	6.5
	250	616 870	3 430	179.85	
B. Lower power cost (–50%)	150	311 880	3 430	90.93	
	200	479 880	3 430	139.91	5.6
	250	647 880	3 430	188.89	
C. Higher power cost (+50%)	150	249.870	3 430	72.85	
	200	417 870	3 430	121.83	7.4
	250	585 870	3 430	170.81	
TO SHOW AN IRR OF 20%:					
A. Basic cost model	150	249 210	3 430	72.66	
	200	417 210	3 430	121.64	7.4
	250	585 210	3 430	170.62	
B. Lower power cost (–50%)	150	280 980	3 430	81.92	
	200	448 980	3 430	130.90	6.5
	250	616 980	3 430	179.88	
C. Higher power cost (+50%)	150	217 450	3 430	63.40	
	200	385 450	3 430	112.38	8.3
	250	553 450	3 430	161.36	

Note 1: (i) Total processing cost = revenue – annual cash available for raw material.
(ii) Revenue = Column (1) x volume of end product (3 360 tonnes).
(iii) Annual cash available for raw material = column (2).
(iv) Processing cost per unit of raw material =

$$\left(\begin{array}{ll} \text{Total processing cost} \div & \text{volume processed} \\ \text{((i) above)} & \text{(column 3)} \end{array} \right) \times (100/1\,000)^{\text{Note 2}}$$

2: Multiply by 100 to give pence per tonne and divide by 1 000 to give pence per kg.

CONCLUSIONS

5.43 This Section has described a method of appraising fish freezing plants when end product prices are known and processing costs other than fish purchase costs have been determined. The method emphasises the computation of the price which can be paid to fishermen for the raw material, given an imposed financial requirement of a set Internal Rate of Return (IRR) to be earned by the plant.

5.44 A comparison between the various cost models can be made by assessing the various prices which can be paid for raw material. Thus it is evident that, with the introduction of a further shift (Model 4 compared to Model 3), scale economies obtain which enable a higher price to be paid to the fisherman. The effects of variations in key process operating costs have also been investigated in this manner.

5.45 Variations in end product prices obviously have a fundamental effect on prices that can be paid for the raw material and this has been clearly illustrated. An alternative method of assessment is to take processing costs exclusive of fish purchase costs and compute the mark-up that would be required to cover costs to earn a set IRR. Such a mark-up has been illustrated for Models 3 and 4 and is reflected in the processing cost columns of Tables 21 and 24.

5.46 In any actual situation where prevailing fish prices are known or are more readily determined it is possible to undertake a more conventional discounted cash flow analysis to assess the viability of any proposed fish freezing plant. It is evident that any benefit arising from scale factors could be reflected, either in a higher rate of return on processing operations or in higher prices paid to fishermen for the raw material, or a combination of these. The same consideration would equally apply to any favourable movement in end product prices.

APPENDIX 1

Labour requirements

	Salary (£/month)	No. of staff Model 1	Model 2	Model 3	Model 4
Manager	500	1	1	1	1
Personal Assistant	100	1	1	1	1
Shift Supervisor	250	2	2	2	3
Clerk/Cashier	100	2	2	2	3
Mechanic	150	2	2	2	3
Tallyman	60	2	4	2	3
Reception					
Foreman	50	2	2	2	3
Labourers	40	10	6	8	12
Freezing					
Foreman	50	2	2	2	3
Labourers	40	26	12	18	27
Cold Store					
Foreman	50	2	2	2	3
Labourers	40	10	4	8	12

Note Model 2 requires an additional 2 foreman and 46 labourers for the prawn line.

APPENDIX 2

Financial analysis methodology

2.1 Introduction

In this appendix the simple method of financial analysis used on the cost models is illustrated. The intention is to show how this report can be used to carry out costings in any particular location using local factor costs to give some indication of the basic economics of an installation in different local situations.

It should be emphasised that, although a simple method of financial analysis is demonstrated to show how the models might be used in, or adapted to, the conditions in different parts of the world, the report is not intended to provide a financial analysis of a particular enterprise operating such installations. Such a financial analysis would require, apart from local factor costs, detailed knowledge of the capital structure of an enterprise (both equity and loan contributions), as well as knowledge of the taxation and depreciation provisions of the country in which it operated. In certain circumstances marketing costs would also have to be included.

2.2 Discounted Cash Flow Analysis

The discounted cash flow method is used to assess maximum raw material prices. This method enables a comparison of costs and receipts over a period of time to be made and summarised as a Net Present Value (NPV). This figure is the sum of the difference between inward (—) and outward (+) annual cash flows discounted at a particular rate over a period of time. Alternatively, the Internal Rate of Return (IRR) can be calculated. This is the discount rate which will equate inward and outward annual cash flows over a period of time, or, in other words, that will give a Net Present Value (NPV) of zero.

This methodology is designed to assess the relative financial viability of the different processing plants to the organisation which might consider establishing them. In particular it provides an estimate of the return to capital investment after recovery of that investment. Hence it enables alternative schemes to be compared and placed in an order of rank from the point of view of financial performance.

The cost models are analysed over a life of 15 years. A residual (or terminal) value is allowed for those items of fixed capital costs with a life extending beyond year 15. The residual value is calculated on a proportional basis according to the number of years of useful life remaining after year 15. In the discounted cash flow analysis the residual value is treated as a cash in-flow and is entered in year 15 as a negative figure being deducted from the cash outflow for that year. Similarly, working capital is recovered in year 15.

Discounting rates of 10 per cent and 20 per cent have been applied in deriving the maximum raw material price. 10 per cent corresponds to the test discount rate adopted by the UK Overseas Development Administration (ODA) for project appraisal and 20 per cent corresponds to a discount rate more likely to be applied as the opportunity cost of capital by an entrepreneur. These discount rates are illustrative and are not intended as a comment on what is appropriate in all circumstances. The selection of the appropriate rate of return should be made through an assessment of local circumstances. The scope of this report is limited to a simple financial analysis. It could be extended to cover an analysis of the Economic Rate of Return (ERR), by using an assumed economic added value attributable to the processed fish products which could not have been realised without proper facilities. This would form the basis of the annual revenue (cash inflow) stream. A discounted cash flow analysis would then have been undertaken to calculate the economic rate of return using shadow priced cash outflow and inflow streams.

The Economic Rate of Return assesses the effect of the project on the economy as a whole, reflecting the opportunity cost to the economy of these inputs used in and outputs derived from the project. The calculation of the Economic Rate of Return

differs from that of the financial Internal Rate of Return, which assesses the financial worthwhileness of the project to the organisation that undertakes it, chiefly in adjusting the values of inputs and outputs to their opportunity cost rather than their market valuation and in making further adjustments to eliminate the effect of transfer payments within the economy, such as taxes and subsidies.

2.3 The Methodology

The following example summarises the steps taken to estimate the maximum raw material price that could be paid to achieve a given internal rate of return. The example is taken from Model 1 (Section 5) and is for the system producing 225 tonnes of raw headless prawns with a factory gate value of £2/kg. The raw material requirements are for 394 tonnes of whole prawns. The costs used are those described in paragraph 5.8–5.14 and summarised in Tables 12 and 13.

Step 1: Calculation of the Discounted Cash Flow Net of Raw Material Costs
This calculation is shown in Table 2.1 and results in an NPV for the project of £2 790 361 for the test discount rate of 10 per cent which has been used.

Step 2: Calculation of the Annual Total Cash Available To Purchase Raw Material
This is the annual amount of cash available to purchase raw material which, if fully used, would increase the annual cash outflow so that the NPV would equal zero, i.e. the IRR (Internal Rate of Return for the project) would equal the discount rate used (in this case 10 per cent).

(i) Look up the appropriate "present worth of an annuity factor" in Appendix 3. In this case the appropriate factor is 10 per cent over a project life of 15 years, i.e. 7.606.

(ii) Divide the total discounted cash flow (net of raw material costs, i.e. £2 790 361 from Step 1) by the present worth of the annuity factor:

£2 790 361 + 7.606 = £366 863[1]
£366 863 is therefore the annual cash available for the purchase of raw material.

Step 3: Calculation of the Unit Maximum Raw Material Price (£/tonne)
The unit maximum raw material price is simply derived by dividing the annual amount of cash available (Step 2 (ii)) by the tonnes of raw material required.

In this case:

£366 863 ÷ 394 tonnes = £931/tonne

Therefore, £931/tonne is the maximum price which can be paid at the factory gate for whole prawns for subsequent processing if an IRR of 10 per cent is to be achieved.

1 – Appears as £366 750 in Table 14, rounding to the nearest £250.

Table 2.1

Example Discounted cash flow (Model 1)

COLUMN	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
YEAR	Fixed Capital[1] and Establishment Costs	Working Capital[2]	Operating Costs[3]	Total Cash Outflow[4] (Net of Raw Material Costs)	Cash Inflow from End Product Sales of Frozen Prawns[5]	Net Cash Flow[6]	Discount Factor at 10%[7]	Discounted Cash Flow[8] (Net of Raw Material Costs)
0	96 100	16 662	–	112 762	–	(112 762)	1.00	(112 762)
1	–	–	66 650	66 650	450 000	383 350	0.909	348 465
2	–	–	66 650	66 650	450 000	383 350	0.826	316 647
3	–	–	66 650	66 650	450 000	383 350	0 751	287 895
4	–	–	66 650	66 650	450 000	383 350	0.683	261 828
5	6 600	–	66 650	73 250	450 000	376 750	0.621	233 961
6	–	–	66 650	66 650	450 000	383 350	0 564	216 209
7	–	–	66 650	66 650	450 000	383 350	0.513	196 658
8	22 440	–	66 650	89 090	450 000	360 910	0.467	168 544
9	–	–	66 650	66 650	450 000	383 350	0.424	162 540
10	6 600	–	66 650	73 250	450 000	376 750	0.386	146 425
11	–	–	66 650	66 650	450 000	383 350	0.350	134 172
12	–	–	66 650	66 650	450 000	383 350	0.319	122 288
13	–	–	66 650	66 650	450 000	383 350	0.290	111 171
14	–	–	66 650	66 650	450 000	383 350	0.263	100 821
15	(3 750)[9]	(16 662)[10]	66 650	46 238	450 000	403 762	0.239	96 499
TOTAL	–	–	–	–	–	–	–	2 790 361

Notes:

1 – From Table 12.
2 – 25% of annual operating costs.
3 – From Table 13.
4 – Costs (1) + (2) + (3).
5 – 225 tonnes at £2.00/kg of end product.
6 – Column (5) – Column (4) (Cash flow net of raw material costs).
7 – From Appendix 3.
8 – Column (6) x Column (7).
9 – Residual value of buildings (25% of £15,000)
10 – Recovery of working capital.

Appendix 3

Example Discounting Table

Rate 10%	Discount factor	Present worth of an annuity factor
Year		
1	0.909 091	0.909 091
2	0.826 446	1.735 537
3	0.751 315	2.486 852
4	0.683 013	3.169 865
5	0.620 921	3.790 787
6	0.564 474	4.355 261
7	0.513 158	4.868 419
8	0.466 507	5.334 926
9	0.424 098	5.759 024
10	0.385 543	6.144 567
11	0.350 494	6.495 061
12	0.318 631	6.813 692
13	0.289 664	7.103 256
14	0.263 331	7.366 687
15	0.239 392	7.606 080
16	0.217 629	7.823 709
17	0.197 845	8.021 553
18	0.179 859	8.201 412
19	0.163 508	8.364 920
20	0.148 644	8.513 564
21	0.135 131	8.648 694
22	0.122 846	8.771 540
23	0.111 678	8.883 218
24	0.101 526	8.984 744
25	0.092 296	9.077 040
26	0.083 905	9.160 945
27	0.076 278	9.237 223
28	0.069 343	9.306 567
29	0.063 039	9.369 606
30	0.057 309	9.426 914
31	0.051 099	9.479 013
32	0.047 362	9.526 376
33	0.043 057	9.569 432
34	0.093 143	9.608 575
35	0.035 584	9.644 159

Note: 1 — Source — 'Compounding and Discounting Tables for Project Evaluation' (1973) ed. J. Price Gittinger International Bank for Reconstruction and Development (IBRD).

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